A Randomized Controlled Trial of a High Intensity Interval Training Intervention using a Body Sensor Network and Facebook

Daryl L Foy

School of Human Movement and Sport Sciences

Masters Human Movement: Bio-Science

Thesis

University of Ballarat

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Acknowledgement

I would like to thank my wife Wilhelmina Martenje Eveleens, son Luka and daughter Yoshe as well as friends Barry Kuch, Malcolm Fletcher and Brian Chilcott for their support and encouragement. Chris Errington and Dr. Martin Single of the University of Canterbury (New Zealand) have been a great source of help and advice. From the University of Ballarat I acknowledge the assistance of Dr. Brendan O'Brien and Dr. Chris Mesagno as my primary supervisors and Dr. Warren Young for his vote of confidence, for without it, the work would never have started. Brendan in particular has been a reliable, patient and insightful coach from start to finish. The study was nothing without the participation and whole hearted endeavour of the Students of Ballarat Hockey Club under the leadership of Cheyne Hackett. Jessica Luke was a lifesaver throughout the pre and post testing phases and worked tirelessly to ensure data collection ran smoothly.

Mike Elmsly and Roger Nesbitt were instrumental in the provision of the SPUTNIK mobile and Facebook applications services that were so essential to the mechanics of the study proper. Their talent, professionalism, good grace and calm demeanour provided a stable backdrop to the study.

The investigative work initiated by this thesis should add to the body of knowledge and provide continued momentum in the coming years as body sensor networks and social networking link with large scale collaborative computing infrastructures in public health to deliver cost effective benefits to those most at risk.

Abstract

Purpose

The purpose of this pilot study was to conduct an impact evaluation on adherence to a 5 week high intensity interval training (HIIT) intervention by the use of a body sensor network and social networking site (SNS) software.

Design

The study design used was experimental, comprised of two-groups with random allocation to each and pre- and post-tests of repeated sprint performance.

Setting

University of Ballarat, Australia.

Subjects

Participants (N = 16) included university student members of a State League 5 field hockey club. The study employed a convenience sample consisting of an intervention group (n=8) and a control group (n=8).

Intervention

Both groups were given a 5 week HIIT program specifically designed to improve performance in repeated sprint activity (RSA). This program comprised twice weekly training sessions over the 5 weeks with gradual increases in training load and concomitant reduction in rest and recovery. The intervention group used a garment with sensors to gather heart rate and accelerometer data (speed, distance and cadence) that published the physiological data via Bluetooth and GPRS to a purpose-specific software application called SPUTNIK which ran on the Facebook social networking site (SNS). This group could socialise their data amongst themselves and share detailed graphical analysis of their training programs. They were also able to set, change and share their goals and comment on each other's training, goals and progress. The intervention group could train together as they required. The control group used a heart rate monitor (HRM) to guide their training sessions and a paper-based

diary to record their training performance data and any goal changes. They trained alone and did not communicate with any members of either group for the duration of the study.

Measures

Dependent variables included scores in a modified pre and post-test Yo Yo Intermittent Recovery Test Level Two and adherence measured as the number of completed sessions from the specified intervention program. Extraneous variable measures included the number of goal changes by each participant and the post-test score expressed as a percentage of their target goal score for the test, treated as goal attainment.

Analysis

A Mann-Whitney U test was carried out between the intervention and control groups on mean adherence (number of sessions) scores. Differences between groups were assessed at pre-test and post-test using univariate analyses of variance. Post-test correlation of bivariate data and regression were completed to identify relationships between the variables.

Results

Yo Yo pre and post-tests revealed a decline in performance means for the control group; μ_0=24.65, $\mu_1$24.56 and an improvement by the intervention group; $\mu_{0=}$23.06, $\mu_{1=}$24.28, variance of scores within the control group increased markedly in the control group; $ð_0$=1.596, $ð_{1=}$ 2.191 and declined in the intervention group; $ð_0$=1.578, $ð_{1=}$ 1.488. The tests showed that there was a highly statistically significant difference between the groups, U=9.00, p<0.05 (two-tailed) such that the level of adherence shown by the intervention group (mean rank=11.38) exceeded the control group (mean rank=5.63). There was also a strong, positive correlation) of (*p*=0.037) between the adherence rates measured as the Number of Sessions completed and the Yo Yo post-test score expressed as a percentage of the Target Goal Score; the intervention group were better able to attain their target goal scores as their adherence was superior.

Conclusion

Despite the limitation of such as small sample size, the study showed that socialising physiological performance data collected by a BSN and managed and analysed by a SNS leads to increased adherence to a 5 week HIIT intervention program with non-elite field hockey players.

Introduction

Background

Accelerated developments in textiles science, nano-technology, wireless networks and large scale web-based data management allied with the proliferation of social networking sites provides the medical, allied health, industrial and military sectors with a catalytic convergence of technology to revolutionise health and well-being practices. A convergence that allows the simple and secure collection of data from on and around the body along with its publication, storage, management, analysis and socialization. The base platform for this convergence is known as a Body Sensor Network (BSN); (Yang, 2006). It typically comprises sensors, wireless data transfer and integration with discrete remote servers via the Internet; a personal server component is increasingly like to be a smartphone.

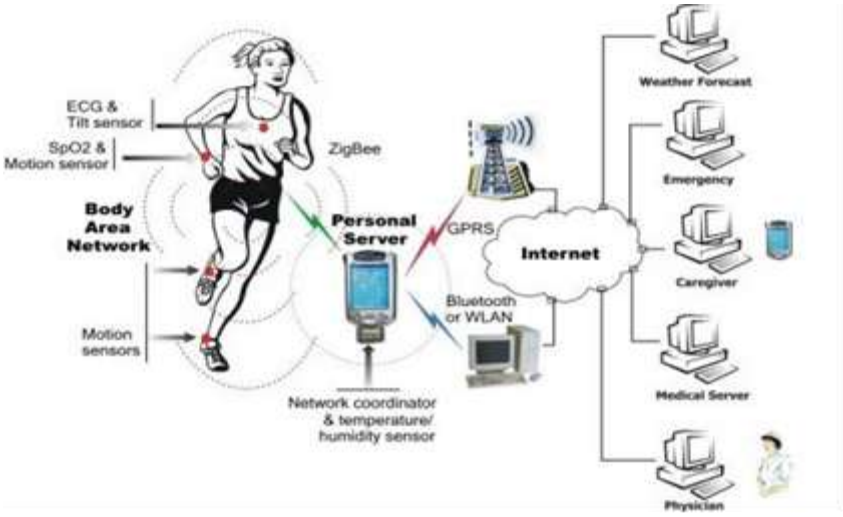

Figure 1.*WBSN-based wearable personal health system.*
Reprinted with permission from Jovanov, Milenkovic, Otto & de Groen, (2005).

At the heart of this new personal information network revolution is the introduction, through advances in material science, of so-called 'smart textiles'. Smart textiles detect and respond to various physiological (e.g. pulse) and environmental conditions or stimuli such as noise. These stimuli can originate from mechanical, thermal, chemical, electrical, or magnetic

sources (Lam & Stylios 2006). Such technology has application in clinical healthcare with chronic disease monitoring and high performance athletic environments including military and first response operators, (Yang, 2006). The most prevalent implementations of earlier generation sports sensors are basic harness-based heart rate monitors, Global Positioning System (GPS) chip-sets and accelerometers. Despite rudimentary functionality and debatable ergonomics these devices are in widespread and successful use in professional sport; (Ward, Evenson, Vaughn, Rodgers, & Troiano 2005). There is currently a rising momentum to extend these basic tools with smart-textile and nano-sensor-based augmentations that incorporate extended physiological vital signs including respiration rate, pulse oximetry, blood pressure and skin temperature. (Coyle, 2010) sees the spin-off from projects such as the EU's BioTex chemical sensors in fibre approach and its provision of real-time analysis of the constituents of sweat in the form of smart re-hydration strategies. Smart textiles are tailor-made to capture kinematic data for athlete feedback that can aid technique improvement, (Coyle, 2009). Such real-time kinematic feedback has application to exercise rehabilitation and ergonomics as well as high performance sport and dance; movement patterns can be assessed and corrected.

In a broader view, the rise of BSNs and Bluetooth wireless technology has coincided with the proliferation of social networking sites (SNS), General Packet Radio Service (GPRS) and mobile, smartphone platforms. This technology has allowed for the mobilisation and socialisation of physiological and location data. What has still to be answered is the nature and extent of measurable benefits to be accrued from the use of these technologies in targeted health and exercise interventions. There is much work to be done to determine exactly what measurable benefits can stem from this technology in practice. What work has been finished to date has shown people who use simple pedometer-based devices in conjunction with seamlessly integrated Facebook based management and monitoring software that enables sharing of performance data enjoy a significant increase in daily step count over peers who do not have access to the socialised data from the system (Foster, Linehan, Kirman, Lawson, & James, 2010). The power of the group as a vehicle for improving physical performance was shown when a group of recreational athletes were able to walk greater distances when they performed a standardised test in a group instead of alone, (Grindrod, Paton, Knez & O'Brien, 2006).

There are dynamic social forces at play when groups perform exercise together; forces that can magnify the physiological benefits of exercise to each member. Cohen, Knight, &

Ejsmond-Frey, 2010 showed rowers in a college rowing crew when training together experienced a greater endorphin surge than with a similar training regime that was performed alone. The research team used pain threshold as the assay for determining the relative levels of endorphin uptake. While the results clearly indicate elevated opioidergic activity when the rowers were exercising in synchronicity, there was no cause identified. The researchers did however speculate that endorphins released in group-based exercise may play a similar role in social bonding as grooming plays in dyadic bonding in primates.

In exploring potential information technology influences on exercise dynamics (Mueller & Agmanolis, 2005) examined the use of a live audio-visual based informatics environment that linked geographically remote recreational football (soccer) players together via what they termed an Exertion Interface. They found that the Exertion Interface users "got to know the other player better, had more fun, became better friends, and were happier with the transmitted audio and video quality, in comparison to those who played the same game using a non-exertion keyboard interface". The findings suggest that an Exertion Interface, as compared to a conventional personal computer (PC) keyboard interface, is superior for optimising social bonding in games-based exercise done remotely. If technology can simulate social proximity and interaction then perhaps cohesion, relatedness and support can follow.

The use of health behaviour models provides a standardised mechanism for eliciting, monitoring and analysing intervention programs as used for both groups and individuals. A foremost health behavioural model gaining favour in sports and exercise science studies is the Self Determination Theory (SDT) which provides answers to questions of participant motivation, intervention adherence, motivation and effective coaching approaches. The provision of both social and environmental conditions that catalyse the satisfaction of the basic psychological health needs of autonomy, competence and relatedness to others will help promote the internalisation of positive exercise behaviours so they are engaged in autonomously and more likely to be maintained in the long term (Wilson & Rogers, 2003). SDT places particular emphasis on the role of motivation in understanding and guiding behaviour. The theory identifies intrinsic, extrinsic and amotivation forms of motivation as directly influencing behaviour, particularly as applied to physical activity. Intrinsic motivation involves participation in an activity for enjoyment, playful fun, interest, stimulation and satisfaction, (Ryan & Deci, 2006). Extrinsic motivation drives participation in order to realise external recognition and reward by way of prizes, cash, status, social approval, averting punishment and mitigating coercion, (Moller, Deci, & Ryan, 2006). There

are two forms of extrinsic motivation. Firstly, non-self-determined motivation in which the individual is acting in accordance with an obligation or possible sanction. In the exercise realm this kind of motivation is seen when athletes respond to the demands of a coach and or parent and comply fully with them. Secondly, self-determined motivation is held by athletes that engage in activity of their own volition, the activity is congruent with their beliefs, goals and outlook. Amotivation means lacking a real purpose for engaging in an activity. These types of motivation are framed as a continuum by SDT reflecting high to low self-determination, (Deci & Ryan, 1985, 2000). In sport, self-determined motivation is integral to optimising persistence, performance and the ability to manage competition stress, (Mallett 2008). Pelletier, Fortier, Vallerand,& Brière (2001), demonstrated that autonomous motivation forms can predict positive persistence behaviours in sport.

Wilson, Rodgers, Blanchard and Gessell (2003), examined the relationships between psychological need satisfaction (competence, autonomy, and relatedness), exercise regulations, and motivational consequences promulgated by the Self-Determination Theory; exploring changes in these constructs over the course of a 12-week prescribed exercise program. They found that competence and autonomy were positively correlated with more self-determined exercise regulations. These were more positively related to exercise behaviour, attitudes, and physical fitness. The study concluded that SDT was a viable theoretical framework to use in studying motivation in sports and exercise. The technology to be used in this study, designed and developed by the author with Roger Nesbitt and Mike Elmsly was built specifically to accommodate the relatedness needs construct of SDT. With a strong and growing body of knowledge that affirms the applicability of the Self Determination Theory (SDT) for assessing and understanding the dynamics of motivation and environment on exercise intervention programs and a technology platform purpose built to implement elements of SDT it was judged to be the preferred choice in providing a theoretical framework for the project.

Similarly, the research literature confirms benefits accrue from using Facebook for supporting exercise interventions. The increasing uptake of Facebook for exercise program support has been boosted by the proliferation of smartphones (Murphy, 2012). In a recent market research report (Murphy) that surveyed five hundred social media regular users who take advantage of the technology to form part of their exercise routines it was found that 51% of them use their smartphones during exercise workouts. From the same survey, it was determined that 75% of the same user base shares their fitness training information on

Facebook. Clearly, the technology may have potential for more structured exercise programs for community groups. Although the path to realising the potential of body sensor networks (BSNs) for health and fitness has been opened through initial forays into pedometer and accelerometer use there has been no published research into the impact on adherence to exercise intervention programs of a more advanced BSN such as a mobile body blogging system. This system seamlessly integrates a BSN and SNS, allowing for socialisation of physiological data; its graphical analysis and commentary along with goal setting management and group communication. It supports, through the social technology mechanisms of group support, interactive dialogue and real-time messaging, graphical and text-based performance data and knowledge, the conditions for helping satisfy the three basic psychological needs of competence, autonomy and relatedness that are prerequisites to an individual's participation in and adherence to exercise interventions (Deci & Ryan, 2002). Understanding and evaluating the nature and extent of any role this convergent technology (BSN and SNS) can play in improving the adherence of competitive athletes training under a sports-specific intervention program, requires investigation.

Problem Statement

Elementary BSN-SNS (mobile body blogging) integrated platforms such as the NIKE Plus system, a simple foot bed-based pedometer sensor integrated with Internet software have revolutionised the training habits of many recreational runners, (Lopes, 2010). Similar research-only systems have, through limited studies revealed that an increase in walking activity accrued by exercisers could be attributed to the socialisation of their performance data using the technology (Foster, et al. 2010). There has however been no study to determine if sharing and analysis of data collected by a BSN and published by mobile phone to a fit-for-purpose SNS software application has a direct and measurable effect on adherence to training programs and performance in standardised fitness tests for repeated sprint performance.

Purpose of the Study

With the maturity and proliferation of enabling technology platforms; body sensors, mobile phones, Bluetooth wireless-based data transfer, GPRS and social networking sites (SNS) there is now an expanding volume of mobilised and socialised physiological and location data. Coyle (2009) and Yang (2006) allude to breakthrough applications of BSNs that stand to revolutionise the sports, fitness and wellness sectors, with commercial products to follow.

There will be a lag until these technologies move from proof to practice. In terms of the available technology what are the measurable benefits to be accrued from their use for specific BSN-based interventions that may positively affect prescriptive health adherence programs?

This study looks to determine the effects of using a BSN-SNS based technology intervention on:

- adherence to a high intensity interval training (HIIT) program designed for field hockey players from the same team
- goal setting and attainment of goals in the performance of a modified Yo Yo Intermittent Recovery Test (Level Two), along with
- assessing the efficacy of the repeat sprint activity (RSA)-based HIIT program on improving performance in a modified Yo Yo Intermittent Recovery Test (Level Two)

Using $H_0\ \theta = 0$.

Where θ = median

Null hypothesis 1 H_0

This asserts there will be a median difference of zero and the Socialisation of Data with BSN-SNS technology will have no significant effect on adherence to the HIIT intervention program.

Alternate Hypothesis 1 H_a

Refutes the null hypothesis 1; Socialisation of Data with BSN-SNS technology will have a statistically significant effect on adherence to the HIIT intervention program.

Null hypothesis 2 H_0

This asserts there will be a median difference of zero and the Socialisation of Data with BSN-SNS technology will have no significant effect on the attainment of Target Goal Scores.

Alternate Hypothesis 1 H_a

Refutes the null hypothesis 2; Socialisation o f Data with BSN-SNS technology will have a statistically significant effect on the attainment of target Goal Scores.

Null hypothesis 3 H_0

This asserts there will be a median difference of zero and adherence to the HIIT program will have no significant effect on the score achieved by participants in the modified Yo Yo Intermittent Recovery Test (Level Two).

Alternate Hypothesis 3 H_a

Refutes the null hypothesis 3; adherence to the HIIT program will have a statistically significant effect on the attainment of target Goal Scores.

Significance of the Study

Determining the presence and potential additive or energising effect on training adherence of socialising physiological performance data graphically and narratively on a social networking site could have widespread impact on sports coaching practices and health intervention strategies. In establishing a positive relationship between the enabling technologies; body sensors, Bluetooth, GPRS and SNS and the high intensity interval training program with its accompanying adherence improvements there arises an opportunity to overhaul the way in which exercise programs are prescribed, measured, communicated, analysed and adjusted.

To collect real-time data that can be instantly shared, analysed and reviewed at minimal cost based on readily available, easy to use technology; a mobile phone and Facebook could serve to reduce the reliance on the high cost, high touch, and face to face presence of coaching and allied health practitioners. This is of particular salience to distributed high performance sports networks reliant upon regional and geographically remote nodes to administer programs and support. For athletes undergoing the rigors of injury-recovery rehabilitation in an isolated setting, their cardiovascular readiness can be assessed accurately and conveniently while ensuring a level of connectedness, relatedness and inclusion with their peer and advisory support networks. This should assist both exercise rehabilitation and conditioning practitioners to make adjustments to prescriptive programs without the athlete having to present each time. By being connected to their peers through mobile distributed computing,

the athlete could be assisted in realising the satisfaction of their basic psychological needs; a mandatory prerequisite to positive mental health and a boost to recovery and rehabilitation.

Operational definitions

Wireless

Wireless means transmitting signals over invisible radio waves instead of wires. Garage door openers and television remote controls were the first wireless devices to become a part of everyday life. Now the cordless keyboard and mouse, PDAs, and digital and mobile phones are common place. The research project makes use of wireless technology in the form of the transmitter found on the shirt used to gather data and the mobile phone worn by the exerciser to receive that data.

Body Area Network (BAN) or Body Sensor Network (BSN)

This consists of a set of mobile and compact intercommunicating sensors, either wearable or implanted into the human body, which monitor vital body parameters and movements.

The data can be forwarded to a hospital, clinic or allied health practitioner in real-time. The vital signs data flow passes a to a main body station, which consolidates the data streams of all sensor modules attached. It transmits the data to a mobile device (wireless enabled watch or smartphone for example), from where they can be forwarded to external application servers.

GPS

The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of satellites placed into orbit. These satellites circle the earth twice a day in an exact orbit and transmit signal data back to earth. GPS receivers process the data and use triangulation to calculate the user's exact location. These GPS receivers are most often found in vehicle navigation systems and mobile phones.

GPRS

GPRS (General Packet Radio Service) is a non-voice service added to 2G telephone networks; it is, one of the 2.5G technology upgrades. It provides the transmission of IP (data packets) over older networks. The most common use of this IP transmission is the publication of data to web servers.

Social Networking Site (SNS)

These are web-based services that allow individuals to (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system. The nature and nomenclature of these connections may vary from site to site; Boyd & Ellison (2007).

Biotex

The BIOTEX project aims at developing dedicated biochemical-sensing techniques compatible with integration into textile. The BIOTEX project is a Specific Targeted Research or Innovation Project (STREP) part of the Sixth Framework Programme of the European Commission.

Bluetooth

Bluetooth is an industrial specification for wireless personal area networks (PANs). Bluetooth provides a way to connect and exchange information between devices such as mobile phones, laptops, PCs, printers, digital cameras, and video game consoles over a secure, globally unlicensed short-range radio frequency. Bluetooth 2.0 is used by the garment worn in this research project as the standard by which its data is sent to the mobile phone or any other paired device.

Social Graph

The Social Graph is the representation of our relationships. Today, these graphs define our personal, family, or business communities on social websites such as Facebook, Twitter, Linked In and MySpace

Social media networks or online social networks

A social network service usually consists of a user, their profile data and their social ties represented as links. Most of the popular social network systems provide facilities to run games, chat and other types of software applications. Social networking sites facilitate the instant sharing of messages, ideas, activities, events and other social interactions; quickly and simply using the web and mobile devices. The most popular social network sites are

Facebook, Twitter and MySpace. The research project investigates the use and application of individual physiological data as displayed, managed, shared and reviewed on the Facebook social network.

SPUTNIK

This is the name of a commercial product that is in effect a shirt with sensors that sends physiological data to a mobile phone using Bluetooth (wireless). The data can then be published via the Internet using the mobile phone where it is analysed, managed and shared on the Facebook social network.

This research project uses the SPUTNIK system to collect, publish, collate share and analyse the physiological data of the study groups.

Geolocation

Geo-location refers to the identification of the real-world geographic location of a mobile device (and the person using it if it is being carried) using the GPS coordinates provided by the mobile phone.

DataSkin

A garment that integrates sensors used to detect and transmit physiological data. This study will use the SPUTNIK product produced for i-RULE by Roger Nesbitt, Mike Elmsly and me.

Exergaming

This is a term used for computer video games that are also a form of exercise. Exergaming relies on technology that tracks body movement or reaction as well as interaction with software functionality. The genre has been credited with upending the stereotype of gaming as a sedentary activity, and promoting an active lifestyle.

Research question and hypothesis

This study aims to address the question:

Does the use of physiological data collected by body sensors then socially networked for management and analysis have a positive effect on adherence to a high intensity interval training-based intervention program, goal setting and attainment and performance in a standardised Yo-Yo Intermittent Recovery Test Level Two?

The hypothesis proposes socialising the physiological data collected during prescribed exercise sessions by sensors and published via mobile phone to a purpose-specific training management, analysis and sharing system on Facebook will positively affect levels of adherence to a prescribed intervention program. This optimised adherence efficacy from socialising performance data should also improve the ability of the individual to score higher on a subsequent standardised fitness test after completion of a prescribed intervention program designed to improve repeated sprint performance. Further, given the dynamics of group cohesion and performance synchronicity, the study should also demonstrate the participants using the BSN-SNS technology and openly socialising their goals will achieve a higher relative realisation of their goals in the post testing phase.

Assumptions

1. Differences in fitness and intrinsic motivation exist between the study participants and between any individuals in hockey teams at any standard.
2. All participants will give their best effort in pre and post-test events and for each exercise session completed in the intervention program provided.
3. All participants have the necessary access to an appropriate training facility (a level grass surface or equivalent) to conduct each exercise session.
4. Participants in the control group did not at any point in time liaise.
5. The equipment will work correctly and provide accurate data.
6. The SPUTNIK software application for both mobile phone and Facebook will work without fail.
7. The Telstra mobile phone network functions reliably throughout the study period.
8. Each participant has understood the rationale and potential hockey fitness-specific benefits possible from adherence to the intervention program.

Delimitations

1. Sample size is restricted by the capital cost of the equipment.
2. The groups are male only.
3. The software used on the mobile handsets can only operate on the SYMBIAN operating system.
4. Operational uptime of the SPUTNIK application software on Facebook is subject to the concomitant availability of the Facebook service itself.
5. Data for performance in the standardised test procedure is collected via pre and post-test processes.
6. Data for participants' in situ goals, exercise performance and any social interactions in the Intervention Group is collected using a log file Dump function inherent in the SPUTIK for Facebook software.
7. Data for participants' in situ goals and exercise performance for the Control Group is collected by manual collation of their paper-based diaries.

Literature Review

The problem domain under study requires a multi-disciplinary framework to fully describe, test, understand and evaluate the potential impact on health and fitness practices of the recently-named body-blogging phenomenon that lies at the heart of it. This framework is evolving rapidly on a daily basis as body-blogging envelopes more applications and potential uses in health promotion, remote care, gaming and elite athlete performance (Fairclough & Gilleade, 2010). The technology is affecting an increasing number of professional disciplines and community services.

Given the scope and boundary interfaces of body-blogging, the literature review looks to tie together theoretical threads from contributory research knowledge bases in electronic telemetry monitors, (ETMs), social psychology; in particular the Self Determination Theory and Goal-Setting, Adherence, Facebook and SNS as well as exercise science and its application to high intensity interval training and repeat sprint activity. The structure of the literature review reflects this.

Exercise Telemetry Monitors (ETMs)

In the last decade, personalised health and fitness monitoring has shifted from clinical and research settings to the general community, propelled by the proliferation of new information and communication technologies in particular 3G, GPRS and wireless technologies including Bluetooth. Physiological monitoring hardware itself has shrunk in size and cost, making the collection of information simple and non-invasive. Real-time and remote monitoring modes have become possible as communication over wireless devices grows more widespread. This convergence of technological trends continues at a rapid pace, enabling individuals the opportunity to learn more about their own physiological responses in health, recreational and high performance contexts. Commonly used ETMs include pedometers and heart rate monitors (HRMs).

Scientific research has lagged behind the explosive growth of body-blogging in the commercial environment. Much of the work that has been done follows on logically from the extensive investigations of the measurable benefits from pedometer use. Although pedometer technology, compared with the BSN-SNS platform is simple, the principles and practices of application to health interventions are similar. (Tudor-Locke, Chan, & Ryan, 2004) investigated the health benefits of a pedometer-based physical activity intervention in

sedentary workers. Researchers recruited 106 participants from five workplaces in Canada where most jobs performed by the participants were moderately to highly sedentary. Using participants as their own control, physical activity measured as pedometer-determined steps per day was compared before and after a 12-week intervention. Changes in body mass index (BMI), waist girth, resting heart rate, and blood pressure were evaluated. It was concluded that the pedometer-based intervention program increased physical activity in the sedentary population. Ring-Dimitriou, von Duvillard, Stadlmann, Kinnunen, Drachta, Muller and Peak (2007), ran a study for 10 weeks of an unsupervised exercise program with groups using either an Exercise Telemetry Monitor (ETM) or not. All study participants completed a 10-week unsupervised endurance exercise training program, selecting their choice of cycling, running, Nordic Walking, walking, swimming, hiking, soccer, spinning, aerobics, step aerobics, or aqua-aerobics). Males in the ETM group significantly improved their maximum oxygen uptake, anaerobic threshold (AT) and peak treadmill running velocities. There was no significant difference in maximal oxygen uptake in the female groups. Running performance at anaerobic threshold increased significantly in ETM versus non ETM groups. This is an important finding as it suggests a positive role can be played by ETMs in assisting the directive structure of an exercise intervention to yield a substantial comparative performance improvement over non-ETM wearing exercisers. The lack of consistency across the gender groups however remains an unsolved issue, as does extrapolating the work to cover heart rate and accelerometer data integrated into one garment and a true BSN-SNS technology environment.

Today, commercially available wearable sensors such as heart rate monitors are able to collect and publish physiological data to dedicated web portals such as imap my run® and Endomondo® for exercise session management , GPS-derived map overlays and interaction with other users; both familiar and unknown to the individual. More recent commercial entrants leverage more generic social networking platforms such as Facebook and Twitter to socialise physiological and location data, albeit in simplistic formats. Currently available wearable sensors are typically integrated into simple harnesses and sewn into the garment proper, with the most successful preserving the user's cognitive, physical and social homeostatic comfort. Brady,Dunne,Tynan,Diamond,Smyth, and O'Hare (2005) found users of wearable sensors are unwilling to wear something that is perceived as uncomfortable or visibly unusual, if it does not offer substantial reward for the sacrifice.

Gatizoulis & Iakovidis (2007) found harness-based smart sensor systems are rapidly being replaced by what is known as Intelligent Biomedical Clothing (IBC) and sometimes referred to as smart textiles. This newer technology utilises piezeo-resistive yarns and optic fibres to provide another seamless integration of sensors, actuators, energy source, processing and communication. New commercial products are affordances, simply another clothing layer rather than the fixed, external harness. This simple matter of ergonomics and comfort may assist in more widespread adoption of the technology for general use in both sport and clinical settings. The question of relative utility based on comfort and ergonomics is crucial to any study being undertaken using the technology as participants are less likely to persist with wearing any device that is uncomfortable and intrusive, directly affecting results. It is contingent upon the wearable smart sensor designer to take into account objective measurement devices such as the Comfort Rating Scale (CRS) devised by Knight & Baber (2005) which incorporates the physiological and psychological variables that need to be considered in maximising effective wear time. The work of Brady,Dunne,Tynan,Diamond,Smyth, and O'Hare (2005) and Knight & Baber raises a key point that has been largely ignored by the ETM studies. The use of garment-based sensor arrays for data collection have all been GPS and accelerometer-only at this point, none of the studies have attempted to address the issue of their use for physiological data collection. Any employment of garment-based sensors has focused on athletes or sedentary groups, none have examined high risk population segments such as the obese and cardio-vascular disease patients. Not a single study has examined the impact of participant comfort and satisfaction with the on-body use of the equipment on any tracked measurement variable such as adherence to a prescribed exercise program. Any sensor-based technology for self monitoring and management should consider the Knight and Baber CRS in its design. If the technology is ill-fitting, ergonomically unsound and uncomfortable it is less likely to be effectively used for any study. None of the studies reviewed have been run over a time period greater than twenty weeks. This may cast some doubt as to the likelihood of such technology being employed for public health interventions based on prescriptive exercise regimes as there is no evidence for long term practical daily use of wearable devices. Not a single study has examined this issue or provided guidance for possible solutions. The current study uses purpose-built garments, designed and developed by the author and based on all six of the comfort descriptors recommended by Knight & Baber in their work. They are athlete-specific and optimised for comfort, egonomics, easy care and ready access to data. The study does not examine the objective assessment of sensor-garment comfort, ergonomics and suitability for

daily use. This remains a vital area of concern that warrants investigation by other researchers.

Armed with this newly available ability to track, analyse, manage and share the health vital signs, location and fitness of individuals over time, clinical and allied health practitioners may have at their disposal a powerful aid to better understand health and the effectiveness of intervention strategies on psychological and physiological wellbeing. With such an understanding, behaviours can be altered and improved and suitable coping strategies and outcomes formulated. As wearable sensors become more ubiquitous there is more scope to automate the collection of physiological data on a longer term basis; opening this data up to sophisticated data mining and AI-based advisory services for health and fitness. While this information may be kept private, new web-based social media technologies allow us to share our data with others introducing new means to shape our behaviour: (Fairclough & Gilleade 2010). The proliferation of devices for collecting data will drive its socialisation and encourage new software application development, particularly in the health sector.

The ability to publish physiological data from garment sensors to social networking platforms may have a positive influence on the accomplishment of performance-specific goals for clinical users and recreational athletes. Hurling, CattBoni, Fairley, Hurst, Murray, Richardson, & Sodhi (2007), evaluated the impact of a physical activity program based on the Internet, Bluetooth-enabled wrist-worn accelerometers and mobile phones with 77 healthy adults over a 9 week period. Participants were randomized to a test group that had access to the technology-based physical activity program replete with peer-to-peer message board, electronic reminders and real-time web-based feedback or to a control group which received no technology or support. The test group performed substantially better than the control group with greater improvements against baseline for intention and expectation to exercise ($p < 0.001$) and perceived control ($p < 0.001$). Crucially, there was a higher level of moderate physical activity in the test group. The work showed a fully automated web-mobile phone based monitoring, motivation and social support system can increase and maintain the level of physical activity in healthy adults.

Similarly, (Consolvo, Everitt, Smith, & Landay 2006), investigated whether technology could encourage physical activity by providing personal awareness of activity level and mediating physical-activity related social interaction among friends. They used daily step count as a measure of physical activity and a mobile-phone based fitness journal they

developed to track and share progress towards a daily step count goal within a small group of `friends. The researchers compared the percentage of days that goals were met between groups sharing their individual data and those who kept that data to themselves, in an endeavour to determine the influence, if any of data socialisation. The group sharing their data was assisted by a more advanced version of the baseline software used by both groups, with additional features such as messaging and commentary on the step counts of others and the facility to see the progress of others towards reaching their activity goals. These features enabled walking performance data to be readily shared amongst the group, at any time. The researchers found that the sharing groups were significantly more likely to meet their goal ($t=2.60$ and $p<0.05$). They discovered that all but one of the participants was motivated by social influence with social pressure, support and communication being the chief classes of influence. The group with access to those software functions that enabled and supported such social influences experienced higher levels of goal realisation.

This work only touched on the potentially valuable positive behavioural support to be leveraged by social networking platforms. Foster, et al., (2010) have since completed a study to determine whether interactions between users via the StepMatron, a Facebook application designed to provide social and competitive context for daily pedometer readings application more successfully motivated physical activity than simply recording daily step counts in a similar application. The study involved ten registered nurses (nine females and one male) all of them employed within the same hospital ward and personally known to each other as friends. To determine whether the social interaction element of the application was necessary over just recording and displaying feedback, the researchers created two conditions; socially enabled and non-social. In the former condition, participants could view each other's step data and make comparisons and comments. In the non-social condition, participants were restricted to viewing their own personal step data. The study design used modified crossover to circumvent any ordering effects. As a consequence, each participant experienced both conditions. The study found that the participants with socially-enabled access who could view their colleagues step data and make comparisons and comments had significant increase in step activity over the other participants in the non-social condition. This finding points to a positive relationship between social interaction over an online social network and the motivation to increase physical activity in a work-based setting. What requires further exploration is the application of the technology and similar study design to the problem of adherence to an intense, compressed training regime using more advanced BSN with athletes

rather than a walking protocol with non-athletes in a workplace setting. Understanding how socialising more comprehensive physiological data amongst a group working through a rigorous high-intensity interval training program (HIIT) affects performance in standardised physical test measures and the setting and management of goals may reveal more about the potential benefits of SNS for adherence.

The BSN-SNS technology framework may not only encourage the formation of ad-hoc, groups, affiliated teams and a raft of social interactions they could, through the implementation of key enabling features provide a basis for enhanced exercise adherence. For example, Kalpakliev and van Halteren, (2009) demonstrated that use of a wireless accelerometer device and a purpose-built Facebook application known as ActiveTeam encouraged people to form teams, set goals and increase their physical activity in striving to reach these goals. The work was not based on a thorough study design and drew on a small sample size of ten work colleagues from within the office of the research team who participated for the study period of thirty days. This simple observational study focused on the number and type of interactions with the ActiveTeam software as a means of not only understanding the nature and extent of any social interactions, but to also provide a test basis for modifications to the software itself. Despite its limitations of sample size and method rigour, the analysis framework proposed by the authors will be invaluable for future dispassionate analysis of such software in both controlled studies and public, commercial applications. The authors tracked and measured physical activity level, the percentage of activity goal achieved, the daily use of the Facebook-based system, the social graph (the map of all social relationships and interactions) and the use of specific functions within the software. This use of software-based metrication is an important step forward in collating, analysing and managing in situ use of device-originated data; dispassionately; particularly as it applies to understanding and evaluating exercise and clinical health intervention programs. More work needs to be done to build on this initial foray to better measure user interaction and software application efficacy as a behavioural intervention with BSNs and SNSs. The development of standard indices and benchmarks is essential in this regard. Instrumenting the software itself is a capability that could encompass the measurement of health behaviour change model components. Such measures could track the objective efficacy of the model under scrutiny.

By extending the reach of BSN-SNS technology to include mobile messaging there may be greater opportunity to positively influence exercise adherence in at risk groups. For example,

Fjeldsoe, Miller and Marshall (2010) evaluated the efficacy and feasibility of a social cognitive theory-based physical activity (PA) intervention delivered to postnatal women primarily via mobile telephone short message service (SMS). This study used 88 women in a randomised 12-week trial and found that the intervention resulted in increased frequency of PA and walking for exercise in post-natal women. What warrants further examination is the role of the mobile phone as both data recipient and data publisher as it can further extend the network coverage and integration of physiological and location data germane to monitoring and intervention.

Modern technologies, in particular the mobile phone and social networking platforms such as Facebook, are forming a new framework for social interactions of all kinds, including direct support of groups and individuals. Social support is seen as a recurrent predictor of exercise adherence in most studies of intervention effectiveness; (Sherwood & Jeffrey, 2000) Oka, King and Young, (1995) examined the types of social support that best predict adherence at different time points during a 1-year endurance exercise program in 269 women and men ages 50 to 65 years. Results indicate that social support specific to exercise was a better predictor of exercise adherence than general social support. The challenge for researchers is to ensure that this exercise-specific social support is provided by software applications that leverage mobile phone and social networking platforms in order to improve adherence levels. What are the most effective social support mechanisms that can be implemented by mobile and SNS software applications? Is it out of hours access, reward and recognition or sharing of experiences using instantaneous multimedia?

Evolution of the SNS environment continues apace, with the Twitter system providing the latest conduit for sharing BSN data and succinct interactive communications on any topic, including health and exercise interventions. (Kendall, Hartzler, Klasnja, & Pratt) in a major study of physical activity commentaries on the Twitter social networking platform found that the two most frequent categories were posts in which users reported (1) evidence of or (2) plans for exercising. Given the explosive rate of adoption of SNS, including Twitter, estimated by (Lenhart, Purcell, Smith, & Zickuhr) as being doubled from 35% of Internet users in 2008 to 61% in 2010, there is emerging both a critical mass and communications multiplex that may provide a globally scalable social support framework that enables health behaviour change, (Kendall, Hartzler, Klasnja, & Pratt). Mobile body blogging then is poised to play a major role in health and fitness practices but exactly how requires more testing and research. This latest raft of research into the health applications of Twitter needs to start to

address the mechanics of implementing suitable behavioural change models and to determine the most appropriate software features and integration points, for example with BSNs, clinical systems and mapping and geo-locations tools for ensuring effective application of such models.

Social psychology

Social psychology is a broad area; the literature review is confined to assessing key subsets of the discipline, in particular the elements of social support, social capital, health behavioural models and goal setting with reference to adherence. Social psychologists recognise social support may work in two main ways; first, in what is known as a main effects model whereby social support exercises positive effects on emotional well-being, anxiety and physiological health; and secondly, the stress buffering model that acts to mitigate the effects of stress. Rees & Hardy (2004) investigated the matching of social support dimensions with stressors as part of examining the main and stress-buffering effects of social support upon factors underlying performance in tennis. They found that players experiencing competition pressure were helped by the perception they had someone to listen to them and provide moral support. Similarly, social support mechanisms were a direct aid to sustaining positive self-esteem under competitive pressure. Having access to a friendly and positive listener able to provide affirmative statements that maintained the player's self-belief was a stress buffering aid. Fraser & Spink, (2002), found that cohesion and social support variables both contributed to the successful prediction of attendance at exercise programs.

Social networks are a real world instantiation of social support and form part of the measure of an individual's social capital according to (Pearce & Davey Smith, 2003) who further speculated that social capital could be associated with health at the community level. Pulman (1995) (cited in Halpern, 2004 p. 1) explains social capital simply as social connections and the attendant norms and trust According to Helliwell and Putnham (2004) social capital, as measured by the strength of family, neighbourhood, religious and community ties, strongly supports physical health and subjective well-being.

Ellison, Steinfeld and Lampe (2007), found that a SNS, such as Facebook, may affect social capital. Participants in the study reported significantly more Facebook use involving people with whom they share an existing off-line connection—either an existing friend, a classmate, someone living near them, or someone they met socially than using Facebook to meet new people. Furthermore, Ellison, Steinfeld and Lampe (2007), demonstrated a clear and positive

relationship between certain kinds of Facebook use and the maintenance and creation of social capital.

For advanced mobile, sensing and social media technologies to play a positive and measurably effective part in exercise intervention strategies, there needs to evolve a greater rigor by researchers and practitioners in centring studies and commercial services around a sound behavioural change framework. It is until only recently that a model of behaviour change and symptom improvement using Internet interventions has been published. Ritterbrand, Thorndike, Cox, Kovatechev, & Gonder-Frederick, 2009, proposed the Ritterband Model, a hybrid of well-established models integrating health belief and social learning married with empirical evidence and clinical experience. This model purports to be capable of effecting changes in health-related behaviours by adherence to the following steps: "the user, influenced by environmental factors, affects website use and adherence, which is influenced by support and website characteristics. Website use leads to behaviour change via different mechanisms of change (e.g., knowledge and motivation). Behaviour change impacts physiology and target behaviours to bring about symptom improvement, and treatment maintenance helps users maintain these gains." (p) The model propounds the view that effective Internet interventions lead to positive behaviour change and symptom improvement through nine nonlinear actions or factors; foremost amongst these factors are the users' individual characteristics such as demographics and beliefs; their environment including family and peers; and the web application itself; it's functionality and features and the manner in which the user interface (UI) enables simple, consistent, effective and satisfying use of the program itself. When software is used as the conduit to a behavioural change program, the model emphasises the crucial role played by a thorough, systematic user interface design process that ensures the software is easy to use, encourages persistent use and effectively delivers the desired functionality. The software must appeal to the target user(s) by taking into account their background abilities, interests and computer aptitude.

Munson, Lauterbach, Newman, & Resnick, (2010), showed that embedding a wellness specific software intervention in Facebook is a viable option for improving adherence rates compared to other Internet-based wellness interventions. Nevertheless, there is scant research regarding the level and types of interaction, discourse or engagement that supervene use of a purpose-built software package using the Facebook social networking platform. The work done on the standard Facebook application alone has borne out the salience of the individual's self-efficacy and self-esteem as a predictor of relative activity. Park, Kee, & Valenzuela,

(2009) discovered information disclosure was substantially predicted by the need for popularity, while levels of trust and self-esteem predicted information control. Mehdizadeh (2010) investigating Facebook interactions showed that individuals higher in narcissism and lower in self-esteem exhibited greater online activity. Sheldon, Abad, & Hinsch, (2011) discovered that Facebook use helps satisfy people's positive relatedness needs (interacting with, connecting to and caring for others) while at the same time social disconnection (dissatisfaction with the frequency and closeness of personal contacts) drives Facebook use.

One of the health behavioural models gaining favour in sports and exercise science studies is the Self Determination Theory (SDT) which provides answers to questions of participant motivation, intervention adherence, motivation and effective coaching approaches. The SDT argues that some behavioural regulations are imposed and others are autonomous and self-endorsed; (Ryan, Frederick-Recascino, Lepes, Rubio, & Sheldon, 1997). A continuum of autonomy is used to classify motivations under SDT; with extrinsic motivations with external regulations representing the non-autonomous or controlled end through to introjected regulation whereby the individual engages in behaviours to feel better about self-worth or to avoid harm to self-esteem. At the most autonomous end of the continuum is identified regulation where the individual personally values the behaviour. Deci, Ryan, & Williams, (1996) maintain that people have a natural tendency toward maintaining their well-being but this can be thwarted by conditions that abnegate the satisfaction of three basic psychological needs. The first of these, autonomy, is defined as an individual being totally assured they have choice and responsibility for their behaviour. The second, competence is referred to as the feeling that you can actually achieve the goals you set yourself and carry out the necessary behaviours in doing so. The third and final need is known as the relatedness of others; this necessitates that the individual has no doubt that they are understood, cared for and valued by others close to them. The provision of both social and environmental conditions that catalyse the satisfaction of these basic needs will help promote the internalisation of positive exercise behaviours so that they are engaged in autonomously and more likely to be maintained in the long term, (Ryan, Frederick-Recascino, Lepes, Rubio, & Sheldon, 1997).

People need a sense of free will and choice when setting exercise goals. They need to understand what information they require and what behaviours to engage in to reach these goals. Feeling they can perform the necessary actions effectively and feel respected and cared for by advisors, coaches and important others will also assist the individual to pursue exercise

goals and adhere to programs of intervention and direction. According to SDT, a person will develop and maintain more self-determined motivation when they have an autonomy supportive environment to operate within. This autonomy support typically takes the form of seeking and acknowledging other people's perspectives, supporting their initiatives, offering choices and providing useful, germane information while at the same time ensuring no external pressure or controls are applied; Ryan et al., (1997).

In any programmatic intervention using the SDT framework, the practitioner/researcher must see the tripartite basic psychological needs are understood and accommodated in a practical sense. Providing positive feedback to participants as a means to strengthen their confidence and motivation and in so doing, deliver competence support. Removing any external rewards, punishments or controls as well as providing a supportive, non-judgmental and positive social environment will help ensure autonomy support for the participants. As a sense of connection and belonging is vital to wellness, participants will benefit from being connected to others who care for them.

Autonomous motivation includes the feeling that self-control is the best way to help oneself make changes while controlled or extrinsic motivation includes being motivated by only external controls such as perceived pressure from others and feelings of guilt. Pelletier et al.(2001) found that more autonomous forms of motivation were predictive of a lower level of dropout or greater persistence over time for elite swimmers adhering to a training program. Applying this finding to individuals adhering to training programs for elite team sports is an area requiring further attention. There is emerging a growing body of evidence that demonstrates improved adherence to health and exercise intervention programs by those participants that experience a greater level of autonomous motivation. Webber, Gabriele, Tate, & Dignan, (2010) examined two types of motivation, autonomous and controlled, and their relationship to adherence and weight loss in a 16-week Internet weight-loss intervention. The study design involved randomizing two study groups of forty members each to a Standard treatment control group or a Motivational treatment intervention group. All participants received a two hour weight loss education session covering diet, and exercise with the recommendations for these activities being identical. Additionally, the Motivational Group were instructed in goal-setting practice, guided journal keeping processes and encouraged to set a weight loss goal. Both groups were given access to a purpose-built website that contained weekly weight loss tips, weekly lesson postings, weekly recipes, a message board feature, and links to self-help diet, exercise, and behavioural modification

resources available on the web. The site also had a link to a personal on-line self-monitoring report form which participants were asked to use to report, at least weekly, daily caloric intake and daily exercise. The website was identical for the two groups with the exception of separate message boards. Webber et al., (2010) found that the majority of participants had a significant increase in autonomous and controlled motivation. Although motivation increased initially for most participants, the group that went on to achieve a 5% weight loss sustained their autonomous motivation between 4 and 16 weeks, while the least successful group experienced a significant decrease in autonomous and controlled motivation over time.

Webber et al., (2010) also found that autonomous motivation at four weeks was a significant predictor of adherence to self-monitoring (maintenance of a diary to log diet and activity) and weight loss. They noted a positive correlation between weight loss at four weeks and autonomous motivation especially when compared to participants who had higher levels of controlled motivation. According to Webber et al., "It appears that the time period between 4 and 8 weeks may be an important window for weight control programs to consider using techniques designed to enhance autonomous motivation, including giving more intense support or different types of interventions, such as activities to enhance autonomous motivation or contact from a weight-loss counselor in the form of e-mails, phone calls, or face-to-face meetings." (p.7)

Providing a means for encouraging autonomous motivation is important for athletes as well as those seeking to lose weight. Adie, Duda, & Ntoumanis, (2008) completed a study of more than 500 adult sport participants with the objective of testing the efficacy of Basic Needs Theory for coach autonomy support, motivational processes and the well/ill-being of adult sports participants. The results showed that coach autonomy support (the level of participant autonomous motivation afforded by the actions, behaviours and performance environment provided by the coach) predicted participant's basic need satisfaction for autonomy, competence and relatedness. In turn basic need satisfaction predicted greater subjective vitality; a greater willingness to train, compete and enjoy the activities with energy when engaged in sport. The applicability of this premise to sport is shown by (Gagne, 2003) who found that elite female gymnasts were more motivated following practices in which they felt relatedness, autonomy and competent. Almagro, Saenz-Lopez.& Moreno, (2010) extended this work to show that not only does coach autonomy support predict the level of intrinsic motivation shown by athletes but it determines adherence levels to exercise programs. Deci & Ryan, (2000) expanded on their SDT to better address and explain the pursuit of goals

concluding that the how and what of goal pursuits has an appreciable effect on both performance and well-being. In the same study they maintain that intrinsic goals are more positively related to mental health and needs satisfaction than extrinsic goals. Any goal pursuit that is underpinned by autonomous regulation will generate better performance and mental health than a controlled regulatory environment. For researchers operating in the BSN-SNS domain, consideration needs to be given to replicating autonomy support in the design and process elements incorporated into any software application intended to improve athlete adherence.

Goal setting

Goal setting is an accepted, highly effective behavioural management technique that is commonly used to guide exercise participation programs for the sedentary and active alike, Weinberg & Gould (2011). Within the SDT health behaviour model, goals are regarded as being either intrinsic or extrinsic in content. Intrinsic goals are those goals that are likely to further self-interest, well-being and values. Extrinsic goals on the other hand are focused on external validations of worth and reward; Sebire, Standage, & Vansteenkiste, (2009). Vansteenkiste, Matos, Lens, & Soenens, (2007) found that extrinsic exercise goals were associated with an increased ego-involvement and less task involvement than goals with a more intrinsic focus. Chatzisarantis and Hagger, (2007) studied recreational and competitive athletes and found that athletes who placed more emphasis on intrinsic goals experienced greater well-being whereas the attainment of extrinsic goals predicted neither greater enjoyment nor wellness. The accomplishment of specific goals is a fundamental measure of efficacy in most intervention studies and programs. Goals are crucial to participant motivation, satisfaction and well-being. They lead to arousal, discovery and use of task-related knowledge (Wood & Locke, 1990). Bandura & Cervone, (1983) discovered the combination of goals and feedback is more effective for task performance than goals alone. For the goals to be truly effective, people need summary feedback to gauge progress against goal. This provision of feedback is essential to those pursuing goals so they can adjust the behaviour, actions and effort direct toward goal realisation; Latham & Locke, (2007). Feedback provides opportunities to confirm and adjust expectations, goal difficulty and complexity. It also provides an opportunity to receive recognition for positive progress toward goal realisation. The practice of scheduling regular evaluation of progress against goals and creating opportunities for feedback helps measure success, adjust methods and approach; Weinberg (2010).

Latham & Locke, (2007) explored further the original principle of the goal-setting theory that states there is a positive linear relationship between a specific high goal and task performance. He found a higher goal requires higher performance for a person to experience positive affect compared to commitment to a lower goal. Mediators of goal setting are generally covered by choice, effort, persistence, and strategy. Goals are moderated by an individual's ability, their commitment in terms of time and effort, the feedback they receive on their actions and behaviours expended in realising goals, the relative complexity of the task and situational factors such as physical (amenities and equipment) and instructional resources as well as environmental conditions.

Jones, Harris, Waller, & Coggins, (2005) explored the view that success in exercise and other health behaviours is largely dependent upon a participant's self-efficacy, their stage of change and expectations of the program. In the study, adult participants ran to improve fitness levels over a 12 week period; the participants had low levels of fitness at the outset, combined with high expectations of the benefits they would get from being involved. In particular, the participants expected highly elevated levels of happiness and confidence to be theirs at the end of the study. At the conclusion of the study however participants had fallen well short of these expected outcomes; with poor adherence levels prevalent. The researchers postulated that the expectation setting of the coordinators of participant recruitment for enlistment may have proffered excessive benefits. Consistent with the work of Seers & Stanton (2001), the study team concluded that high initial expectations may motivate initiation but can disrupt behaviour maintenance once initial expectations are violated.

In sport settings, public posting of goals (freely disclosing goals for a specific activity in a public place such as a wall in a building with free and common access or on a Facebook page or similar) is often combined with goal setting to improve the performance of athletes (Ward & Carne, 2002). (Hayes, et al., 1985) found that setting goals is more effective than not setting them, short-term goals are more effective than longer term goals, and coach and self-set goals are similarly effective. These findings are particularly relevant when applied to short term, high intensity sports specific conditioning programs where the compressed time frame and workload are typically based on measured workloads and recovery cycles with a view to quick improvements. Setting achievable and measurable goals is a necessary first step in any intervention program, but without adherence to the program protocol there is little chance of goal realisation. What requires additional investigation is how do group cohesion, support and shared disclosure of goals amongst members affect the relative difficulty of goals set;

will team members increase or decrease their goals once they have posted and socialised their initial targets? Does having access to fitness and performance information in real-time affect the difficulty of goals set?

Adherence

For exercise interventions, adherence is the extent to which exercisers follow the prescriptive program processes and session patterns to completion, (Oman & King, 2000).

Oman & McAuley, (1993) explored the relationship between intrinsic motivation and exercise behaviour in participants participating in an 8-week aerobic fitness program. Prior to and following the program intrinsic motivation was measured, it was found to be significantly associated with attendance and participant's confidence in their intentions to continue exercising post-program, and thus adherence. . The more prominent health behaviour models including SDT and the Social Cognitive Model (SDM), point to self-efficacy and self-motivation as key individual attributes that affect optimal adherence levels; competence and self-belief are also consistent factors in predicting longer term exercise adherence, (McAuley, et al., 2003). Clearly then, exercise participants are more likely to adhere to prescriptive programs if they enjoy task mastery and competence along with autonomous motivation, It also helps if the prescriptive program is fun. Garcia & King, (1991) highlighted the need to ensure the exercise program prescribed provided enjoyment for all participants. Many daily considerations may act to conspire against exercise adherence; Weinberg & Gould, (2011) list time, injury, work and family commitments, and lack of training partner and or a support network along with inadequate or no suitable training facilities as the most common considerations. The onus on researchers and practitioners is to ensure the program is sufficiently enjoyable and takes into consideration potential barriers to adherence.

Any exercise prescription designed to invoke substantial change in physiological variables be it for health or performance sport can be challenging. Tackling a program on your own as opposed to working with a group has been found to deprecate adherence and enjoyment; and increasing the level of challenge for the solo trainer; (Weinberg & Gould, 2011). A consistent conclusion by researchers of group exercise interventions has been that the individual's attraction to a group, and the group's exercise-based task, is associated with increased adherence to an exercise program, (Annesi, 1999). Other research has addressed social aspects of sharing information about activity and found that exercising together can also motivate individuals to do more activity; people increase their activity level as they engage in

the light competition Tudor-Locke (2002). Stephens & Craig, 1990 (cited in Annesi 1999, p 544) concluded most adult participants would prefer to exercise with others rather than alone and Massie & Shephard, 1971 (cited in Annesi 1999, p 544) found group-based program attendance exceeds individually based programs.Christensen, Schmidt, Budtz-Jørgensen, & Avlund.(2006) identified two crucial group factors that directly influence exercise adherence ; group cohesion and social support. Cohesion can be defined as "a dynamic process that is reflected in the tendency for a group to stick together and remain united in the pursuit of its instrumental objectives and/or for the satisfaction of member affective needs" (Carron et al.,1998, p. 213). Although both cohesion and social support act in unison as part of group dynamics they are discrete and independent factors, Courneya & McAuley (1995). Christensen, Schmidt, Budtz-Jørgensen, and Avlund,(2006) examined this as part of a study aimed at creating a social framework to encourage urban residents to participate in exercise and providing the pre-conditions for establishing a social support network for residents feeling social isolation, The intervention used comprised thirty two weekly physical exercise lessons of ninety minutes duration with additional social activities included with each lesson. The researchers found that the formation of group cohesion was influenced by the social composition of the group, the teaching ability of the instructors, and the nature of the activity itself. The cohesive group displayed consistent mutual support for exercise tasks. This kind of support enabled evolution of self-efficacy beliefs, subsequently lifting the mastery expectation for exercise of the participants. In the process of determining that mutual social support toward exercise activity originated in the cohesive group, the researchers also demonstrated that although the two social constructs of cohesion and social support seem to act in concert, they are best treated separately. Social support is related to the perception and/or reception of required supportive behaviours that may, or may not, result from the group, whereas cohesion focuses on the group encouraging it to stick together ; (Christensen et al., 2006).

Although improving results for exercise participation requires conditions that amerliorate strong group cohesion and social support, they are not the only factors to consider in optimising adherence to an exercise program. King et al, (1992) pointed out, the variables that directly influence physical activity levels do not operate in isolation one from one another, they are interdependent. Jennings, (2010) in studying successful hypertension interventions derived a list of important factors to consider in order to optimise adherence which include choosing effective, research-proven methods, tailoring interventions to the

individual, setting realistic targets and key progress milestones and clearly and consistently communicating the reasons for the program and the methods or approach used.

For exercise scientists and sports psychologists, optimising adherence may also require attention to the volume and fidelity of any exercise prescription. PerriAnton, Durning, Ketterson, Sydeman, Berlant,and. Martin (2002) investigated the effects on adherence of prescribing exercise at moderate versus higher levels of intensity and frequency. The study was based on a large sample size of three hundred and seventy nine sedentary adults randomly assigned in a two by two design to walk thirty minutes per day at a frequency of either three to four or five to seven days per week, at an intensity of either forty five to fifty five percent or sixty five to seventy five percent of maximum heart rate reserve. The researchers found that prescribing a higher frequency increased the accumulation of exercise without a decline in adherence. In contrast, prescribing a higher intensity decreased adherence and resulted in the completion of less exercise. A contributory factor to the poorer performance of the high intensity group was identified as a higher incidence of exercise-related injuries experienced by this group. An important limitation of this study was the use of sedentary rather than active or high performance athletes as participants. There may be a reduced level of exercise-induced injury in more active participants who enjoy greater fitness levels as well as a pre-existing conditioning base and concomitant mental and physical preparedness. The question of adherence levels to intense interval training amongst athletes as opposed to sedentary people warrants further investigation.

High intensity interval training and repeated sprint activity

Time compression in modern life makes it difficult for the exerciser to balance work and life stresses. This may provide an opportunity for consideration of time-friendly protocols such as High Intensity Interval Training (HIIT) when framing exercise intervention strategies. According to Gibala & McGee, (2008) HIIT is a potent time-efficient strategy to induce numerous metabolic adaptations usually associated with traditional endurance training. Their research has shown that a relatively small number of training sessions (around six) of HIIT over a 2 week training period or an equivalent total of only 15 minutes of highly intense exercise, can increase skeletal muscle oxidative capacity and improve endurance performance. Gormley, Swain, HighSpina, Dowling, Kotipalli, & Gandrakota,(2008) also showed that when the volume of exercise is controlled, higher intensities of exercise are more

effective for improving maximal oxygen consumption than lower intensities of exercise in healthy, young adults.

Contrary to previously held popular beliefs amongst the wider community, short-burst, intense exercise activity not only yields high fitness gains but has also been found to be enjoyable with the bonus of enabling session completion in short times. Bartlett, et al., 2011 studied a group of athletes training using HIIT and moderate intensity continuous running regimes and showed clearly that ratings of perceived enjoyment after exercise were higher following interval running compared with continuous running. (Paton & Hopkins, 2004) concluded that HIIT (along with explosive resistance training) when incorporated into training programs of low intensity produces substantive performance gains. The specific physiological performance parameters that stand to be improved by adopting HIIT into an exercise program include peak maximal oxygen consumption, first and second ventilatory thresholds and anaerobic capacity; (Laursen, Shing, Peake, Coombes, & Jenkins, 2005). (Macdougall, et al., 1998) demonstrated that after HIIT, significant improvements were seen in supramaximal treadmill run time, repeated sprint performance and maximum oxygen consumption; the proportion of type II muscle fibres increased significantly. These results demonstrate that 6 weeks of short sprint training can improve endurance, sprint and repeated sprint ability in participants.

For field hockey players in particular, the game specific benefits to be accrued by aligning HIIT with the (RSA) base pattern of the sport are significant. Hockey players are required to repeat high intensity sprints in quick succession when playing. If the physiological and metabolic responses of repeated-sprint protocols are to be specific and relevant to field-based team sports, then the sprint and recovery durations should replicate the movement patterns of these sports (Spencer, Bishop, Dawson, & Goodman, 2005). Although the mean recovery time between sprints is approximately two minutes during the game of hockey (i.e. a mean of 30 ± 12 sprints performed during the 70-minute game), nearly 25% of the recovery periods between sprints were of <21 seconds in duration. The definition of a repeated-sprint bout used here by Spencer et al., (2005) was a minimum of three sprints with a mean recovery duration between sprinting of <21 seconds. The mean number of repeated-sprint bouts reported during the field-hockey game was 4 ± 1 and 2.1 and the mean recovery time between sprints was 14.9 ± 5.5 seconds. From the same study, the average maximal sprint duration is four seconds. These findings need to be applied to a structured hockey-specific HIIT program designed to improve RSA performance.

Although the Intervention Program used in this study was limited to a 5 week period, studies completed by Burgomaster, et al., (2008) suggests high-intensity interval training is a time-efficient strategy to increase skeletal-muscle oxidative capacity and induce specific metabolic adaptations during exercise that are comparable to traditional endurance training. This finding is consistent with the work of Hunter, O'Brien, Mooney, Berry, Young & Down (2011), that showed intermittent peak and peak running speeds along with a 300m shuttle performance run improved significantly amongst Australian Rules footballers subjected to a four week repeated sprint training program. Along with framing an appropriate duration for any exercise intervention program intended to significantly improve RSA total work output, the fidelity of the prescription is also crucial in optimising performance gains.

Edge, Bishop, Goodman, & Dawson . (2005), ran a study with twenty female athletes and assessed pre- and post-training, for maximum oxygen uptake, lactate threshold (LT), and RSA (using a protocol of five repetitions of sex second maximal sprints, every thirty seconds). Before and immediately after the RSA test, muscle biopsies were taken from the vastus lateralis. Participants were matched on RSA, randomly placed into the HIT group of ten members or moderate intensity continuous training (MIT) group of ten members and completed a five week cycle training program with training sessions held three days per week. They performed either HIT or MIT sessions as part of the program. The researchers found that both groups had significant improvements in oxygen uptake and LT, with no significant differences between them. Both groups also had significant increases in RSA total work but there was a significantly greater increase following HIT than MIT (13 vs 8.5%, respectively; $P < 0.05$). This suggests, along with the work of Spencer et al., (2005) that any program designed to improve RSA output needs to be based on a tailored HIIT program rather than MIT.

Conclusion

Scrutiny of the available research literature has revealed that use of a sound health behaviour model underpins the likelihood of improved adherence to exercise programs, Weinberg and Gould (2011). These models also identify clearly the pivotal part to be played by optimising participant motivation through enhancing autonomy, competence and the relatedness and social support of significant others; (Ryan, Frederick-Recascino, Lepes, Rubio, & Sheldon, 1997). Removing the hindmost of these underpinnings from an intervention program could affect its efficacy; for example a lack of relatedness and social support can deprecate

performance of college football teams, (Garland & Barry, 1990). While goal setting alone is a powerful influence on exercise behaviour, Weinberg & Gould (2011), it is goals set and shared in public that are able to be monitored, eliciting feedback against target that are even more decisive than goals set in private; (Ward & Carne, 2002).

Foster et al., (2010) and (Munson et al., 2010) are the latest in a growing of research efforts into the applicability of SNS to both specific and generic challenges in effecting behavioural change in health. The evidence and promise are immense. Facebook and other SNS are fast emerging as tools that can fit smoothly into health behaviour models and should, through their facilities to offer social support, feedback, public goal setting, rewards and relatedness provide cost effective means for health and fitness practitioners reach looking to improve adherence and extend programs. For these practitioners then attention may need to be paid to exactly how a SNS implements the key factors of behavioural change models such as SDT; there should be a focus on software features and program processes that enable group cohesion, social support, goal setting and adjustment, self-monitoring and autonomy.

For users of Facebook and other SNS-based health and fitness applications, new and dynamic forms of social capital may accrue, Ellison, Steinfeld and Lampe (2007). This could provide added incentive and value to engaging in programs and connected groups brought together on a SNS platform along with the potential adherence boosts. With the growing availability, affordability, utility and interoperability of BSNs; (Yang, 2006) there should follow a proliferation of software affordances to better enable the general public, the health system and fitness industry to take advantage of BSNs. There appears to be from the literature a framework to design, develop and pursue an intervention adherence and efficacy study that combines a technology platform and high yield, compressed time-frame exercise program that exploits BSN and SNS. What is essential is that this technology and program be modelled and managed in a way that effectively magnifies relatedness to others, facilitates group support, enhances social capital, enables public goal setting and displays and manages positive feedback to improve adherence.

Method

Participants

The study looked to determine the relative adherence to a sports-specific interval training intervention achieved by an Intervention Group training together using socially networked physiological data that is shared and analysed in near to real-time and a Control Group training individually and using conventional heart rate monitors with their training intervention data manually recorded in a paper-based diary and not shared. The study drew its twenty (20) participating members from the Students of Ballarat Hockey Club after a Plain Language Information Statement (Appendix A) was released to local hockey clubs. The participants provided written informed consent to the experimental procedures after the possible benefits and risks of participation were explained to them. The study protocol was approved by the Human research ethics committee of the University of Ballarat. These participants are known to each other and have a relatively stable culture based on normalised values, standards and behaviours. They all play at the same standard i.e. regional "A" grade club hockey. Larger samples sizes are required to draw more robust conclusions for any pertinent correlations that are uncovered by the study. The characteristics of the participants are detailed in Table 1.

Table 1 *Characteristics of Study Participants*

	Group					
	Control			Intervention		
	N=10			N=10		
Measure	Mean	StDev	Median	Mean	StDev	Mean
Age	19.90	1.59	20.50	20.40	1.83	20.00
Height	178.80	5.94	178.00	182.00	6.68	182.00
Weight	73.40	5.44	74.50	73.40	10.24	75.50
Yo Yo 1	24.10	1.691	23.56	24.12	1.426	22.50

Experimental protocols and procedures

The study design used was-experimental, comprising two-groups with random allocation and pre-test and post-tests conducted on both.

Measures and covariates

The Independent Variable = Socialisation of Data

The Dependent Variables = Yo Yo Test Score

= Number of Sessions in the Intervention Program

= Yo Yo Test Score (2) as a Percentage of Goal Score (referred to as Goal Attainment)

The Extraneous Variable = Number of Goal Changes recorded at the end of Week One of the Program

The Controlled Variable = High Intensity Interval Training Intervention Program

The Goal measure was the target performance level expressed as a Test Score in the Yo Yo Intermittent Recovery Test.

Goal changes were defined as the number of instances a participant altered their original goal. Goal Attainment was measured as an expression of the Yo Yo Test Score 2 in reference to the participant Goal Test Score in percentage terms.

Experimental interventions and technologies

The participants were instructed to arrive at the gym in a rested and hydrated state and to avoid strenuous exercise or alcohol in the 48 hour period before the pre- test session. Participants were also asked to take note of the food and liquid ingested for the two days prior to the pre-test session and to try as much as possible to replicate this diet before the post training session at the conclusion of the intervention program. After all participant age, weight and height data were collected, the participants were briefed on the exact process to be used for the Yo Yo Intermittent Recovery Test (Level Two). A demonstration was held to familiarize all participants with the test proper and the measurements and recording processes and output were explained. Participants were organized to run in five groups of four by

random selection. There were four recorders used to capture participant scores and a judge to determine compliance and to adjudicate on and signal the point of test exit for each participant. The test was run on a standard timber floored gym in mild conditions of 22 degrees Celsius.

The test process used was the Yo Yo Intermittent Recovery Test (Level Two). As hockey is a sport with extreme levels of maximal repeated sprint efforts, the test provides a fair and thorough evaluation of an individual's ability to repeatedly perform intervals over a prolonged period of time. The participants were provided with a classroom tutorial on the procedure and a first-aid trained staff member was on hand to help with any participants who become physically distressed. The research staff demonstrated the execution of the test to all participants prior to the test proper.

Equipment

The gym provided a flat, non-slip surface. Marking cones and measuring tape were used to layout and measure the interval sections to be run. A pre-recorded audio mp3 file running on an Android tablet and linked via USB port to a speaker system provided the aural guidance for the test procedure. Recording sheets were used by the research staff to log all data prior to entry into Microsoft Excel and SPSS.

Procedure

Cones were used to mark out three lines; 20 meters and 2.5 metres apart. The participant started on or behind the middle line, and began running 20 m when instructed by the mp3 audio file. The subject turned and returned to the starting point when signalled by the recorded beep. There was an active recovery period of 10 seconds interjected between every 20 meter (out and back) shuttle run, during which the subject walked or jogged around the other cone and return to the starting point. A warning was given when the subject did not complete a successful out and back shuttle in the allocated time, the subject was removed the next time they did not complete a successful shuttle. The participants ran in groups of 4.

Scoring

The athlete's score was the total distance covered before they were unable to keep up with the recording. The detailed Yo Yo Intermittent Recovery Test (Level Two) scoring table is provided in **Appendix C**.

As the test required maximal exertion; participants were given the benefit of the doubt in the issuing of warnings, dismissals and disqualifications. Each participant's score was recorded and shared with them in private after they had been randomly allocated to either the Intervention or Control Groups.

Following conclusion of the test and a 5 minute recovery and rehydration period, all participants were assigned by randomization to either a Control Group or an Intervention Group. Both groups received identical exercise science information to explain the rationale behind the Intervention Program; they were then trained on the use of the respective technologies with each group completing their respective training in temporal and physical isolation from the other

The participants in the Control Group had no social interaction online or off-line with the Intervention Group; they also had no interaction with the research team after the pre-test stage. The Intervention Group was neither encouraged nor discouraged to socialise in any form or at any stage including the idea of training alone or together. Both groups were equipped with the necessary background knowledge detailing the nature, structure and applicability of the high intensity interval training (HIIT) program to their sport. Each group was given the same high intensity interval training program focused on speed endurance and tailored to the specific alactic and aerobic demands of field hockey motion patterns as determined by Spencer, M, Bishop, D, Dawson, D, & Goodman, C. (2005).

The Intervention Group

This group used SPUTNIK (DataSkin) garments and mobile phones to collect data and publish it to SPUTNIK on Facebook where they graphed, analysed, shared and commented on each other's training while the Control Group used a heart rate monitor (HRM) for measuring and manually recording their training session performances. The Intervention Group trained normally according to the Intervention program, and wore a DataSkin linked to their mobile phone, to constantly monitor their training. Physiological data was uploaded at the end of each prescribed session of the Intervention Training Program to Facebook, and participant interactions encouraged. A detailed description of the SPUTNIK system is

provided in **Appendix E**. For ease of data entry and analysis and to minimise recording errors each training session detailed in the Intervention Program were encoded as follows:

Use initials of participant name as a prefix added to W (n)-S (n) where:

W = week

S = session

n = ordinal number

e.g. W4S2 is Week 4 Session 2 and PJMW4S2 is Paul John Williams Week Four Session two

Control Group

This Group consisted of ten (10) participants equipped with a Polar Heart Rate Monitor. The heart rate monitor (hrm) was used to record maximum, minimum and average heart rate for each training session described in the intervention program. All participants randomly selected and allocated to this group received training in use of the recording unit and the paper-based diary. The heart rate data was recorded in a paper-based diary using pre-formatted tables along with weekly training goals, program participation goals and any contextual information including feelings, concerns and issues about the intervention program itself or the individual's participation in same in a narrative form.

Intervention program

Designed specifically to cater for the physiological and metabolic responses of hockey, the intervention program used repeated-sprint protocols with sprint and recovery durations that aimed replicate the movement patterns of the sport; Spencer, Bishop, Dawson, & Goodman (2005). This capacity-focused program aims to extend the length of time that the anaerobic alactic system contributes to game related running activity. Although the program is limited to a 5 week period only, studies completed by (Burgomaster, et al., 2008) suggests that high-intensity interval training is a time-efficient strategy to increase skeletal-muscle oxidative capacity and induce specific metabolic adaptations during exercise that are comparable to traditional endurance training.

The participants were restricted to work periods of 10 to 12 seconds maximum, with a rest period set at 6-10 times the duration of the work period to start and slowly moved towards 4 times the work interval by the end of the program. For example, a program session with a 10 second sprint had a rest time of 50-60 seconds, on average. Participants were encouraged to

complete the interval work so that the pace or power output for each work segment of the interval was consistent. Once the participants could complete a full training session with less than a 10% speed drop from their first interval to their last interval they were able to cope with a decrease in the rest period. The rest period was less than that used in field hockey speed and agility work. The work volume was calibrated according to total work time; a target volume of 4-6 minutes pre-set was accomplished by participants doing several sets of 60s-80s work per set. At the end of each set participants took a 5- 10 minute break, comprising of a walk or slow jog. The work and recovery guide for the program follows: workout can be seen in Table 2 below.

Table 2. *HIIT intervention program detail*

Week	Session	Work	Rest	Pause
1	1	10 x 8s	60s	6 minutes
		12 x 6s	40s	6 minutes
		8 x 10s	60s	6 minutes
2	1	12 x 5s	40s	6 minutes
		10 x 3s	30s	6 minutes
		8 x 5s	40s	6 minutes
	2	12 x 8s	75s	6 minutes
		12 x 6s	40s	6 minutes
		10 x 8s	70s	6 minutes
3	1	12 x 5s	30s	5 minutes
		12 x 3s	30s	5 minutes
		10 x 5s	40s	5 minutes
		8 x 8s	75s	5 minutes
	2	12 x 8s	60s	5 minutes
		12 x 6s	35s	5 minutes
		12 x 5s	65s	5 minutes
		6 x 129s	75s	5 minutes
4	1	10 x 5s	25s	5 minutes
		10 x 3s	25s	5 minutes
		12 x 5s	30s	5 minutes
		12 x 3s	20s	5 minutes
	2	12 x 8s	60s	5 minutes
		12 x 6s	30s	5 minutes

Week	Session	Work	Rest	Pause
		12 x 10s	60s	5 minutes
		6 x 12s	65s	5 minutes
5	1	10 x 5s	25s	4 minutes
		10 x 3s	25s	4 minutes
		12 x 5s	30s	4 minutes
		12 x 3s	20s	4 minutes
		10 x 8s	50s	4 minutes
	2	12 x 8s	50s	4 minutes
		12 x 6s	30s	4 minutes
		12 x 10s	50s	4 minutes
		6 x 12s	60s	4 minutes
		8 x 6s	30s	4 minutes

Both groups undertook an end of program Yo-Yo Post Test after 5 weeks. The Intervention Group had their data, and SPUTNIK activities including commentary logged silently by the SPUTNIK Facebook software. The data was analysed to determine:

- Number of sessions completed vs number of sessions set (adherence).
- Number of times goal target score was changed by the end of week one of the program.

The training diaries of the Control Group were collected and analysed for:

- Number of sessions completed and recorded vs number of sessions set (adherence)
- Number of times goal target score was changed by the end of week one of the program

The Yo Yo Intermittent Recovery Test (Level Two) process was replicated in full after the 5 weeks of the Intervention Program had elapsed with conditions as close as possible to the pre-test situation; same location, similar time of the day, similar climatic conditions and presence of vocal support and encouragement for all participants.

The following data was recorded at the post-test and entered into Microsoft Excel for multivariate analysis and SPSS ver. 18 for univariate and bivariate analysis:

- Score for Yo Yo Post-test.

- Percentage of goal target score reached in Yo Yo Post - test

Data analysis

The small sample size and the skewed nature of the distribution precluded the use of a standard two sample t-test. The significance levels of the differences between the medians of the groups were evaluated with the Mann-Whitney U test and a significance level of $p<0.05$ was set. A bivariate Pearson correlation of coefficients was derived and following logarithmic transformation of the skewed data distribution, multivariate regression analysis was conducted. The univariate analyses was done using PASW Statistics (SPSS) version 18.0 and the multivariate analysis completed using Microsoft Excel (2010).

Results

Preliminary analysis

Descriptive statistical analysis of the study participants' performance in the Yo Yo Intermittent Recovery Test Level Two pre-test stage below shows a non-Gaussian distribution.

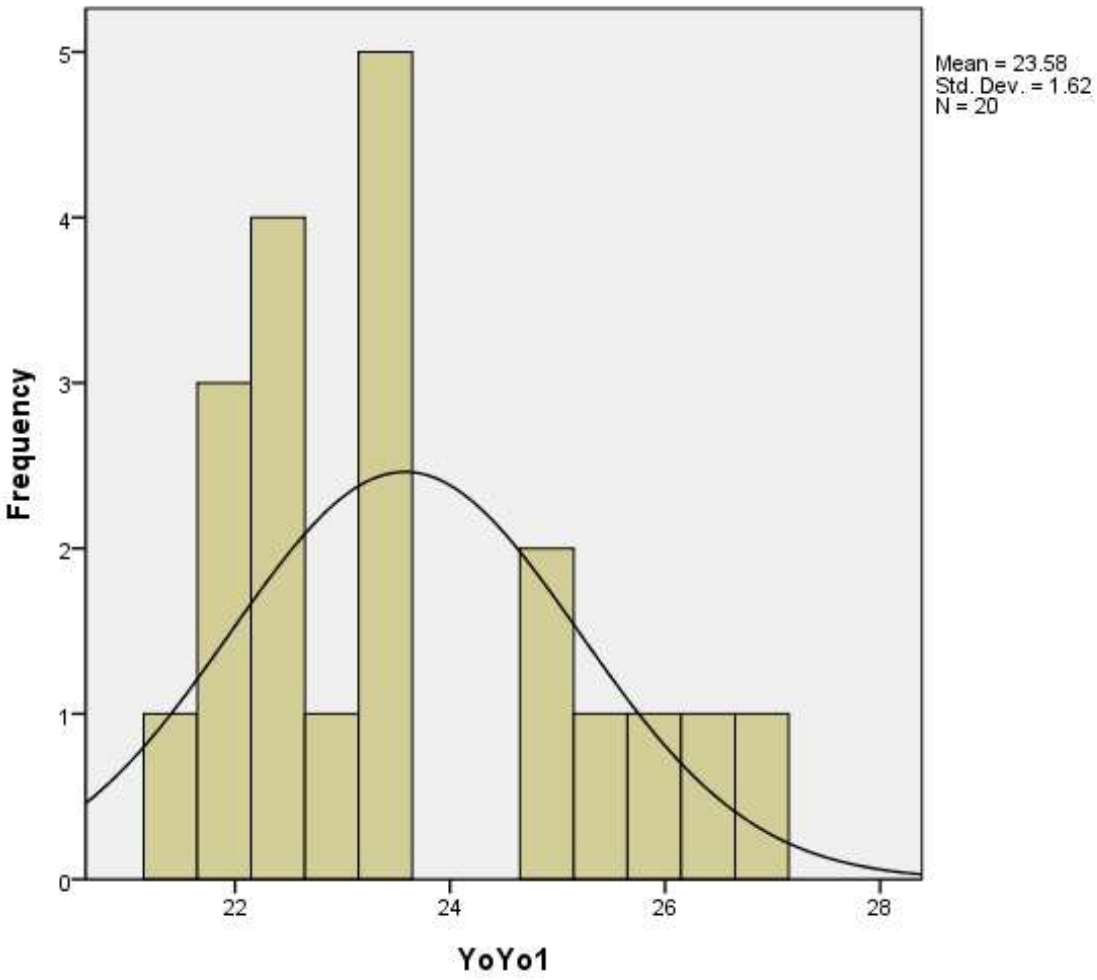

Figure 2. *Non-Gaussian distribution of Yo Yo pre-test scores.*

Appendix F provides a detailed variance analysis of the Yo Yo pre-test scores with boxplot graphics.

Main analyses Adverse events

Two participants in each group dropped out of the program within 2 weeks of commencement due to illness and injury. Due to work relocation, two participants in each group were unable to attend the centralized post-testing phase and completed the post test phase on the same day at the same time under supervised conditions most approximating the centralized test but in remote locations.

Yo Yo test score comparison pre vs post-test results

Yo Yo pre and post-tests revealed a decline in performance means for the control group; μ_0=24.65, $\mu_0$24.56 and an improvement by the intervention group; $\mu_{1=}$23.06, $\mu_{1=}$24.28.Similarly, the Mann-Whitney U test shows the Mean Rank and Sum of Ranks scores for the control group declining from pre-test to post-test; with Sum of Ranks for the control group dropping from 87.50 to 73.00 and the intervention group Sum of Ranks improving from 48.50 to 63.00; $p<0.05$ (two-tailed). The detailed tabular analysis for this is provided in **Appendix F**.

Null hypothesis 1 H_0

There will be a median difference of zero and the Socialisation of Data will have no significant effect on adherence to the HIIT intervention program.

A Mann-Whitney U test of median difference between the groups showed the intervention group with a Sum of Ranks for Num Sessions of 91.00 clearly outperforming the control group which returned a Sum of Ranks of 45.00. The results show that the participants in the intervention group returned a significantly greater adherence to the HIIT program intervention than the control group ($p<0.05$). Further analysis shows a positive correlation between group membership and the Number of Sessions completed (r=0.647). Subsequent processing using the Mann-Whitney U test with the Yo Yo pre and post-tests results shows clearly that the intervention group, with its higher adherence showed an improvement in Yo Yo test. Both the correlation tables and the Mann Whitney U test results are detailed in **Appendix F** and show the group that better adhered to the 5 week RSA-specific HIIT program requirements; the intervention group, improved their performance in the Yo Yo Intermittent Recovery Test (Level Two). Simple regression testing results were consistent

with the univariate and bivariate findings showing the intervention group did 70% better on average for adherence (measured as Num_Sessions) than the control group.

From the analyses then, the null hypothesis, H_0 can be rejected and we can conclude the alternate hypothesis, H_a holds true and socialising physiological data on a SNS increased adherence to a HIIT intervention program.

Null hypothesis 2 H_0

This asserts there will be a median difference of zero and the Socialisation of Data with BSN-SNS technology will have no significant effect on the attainment of Target Goal Scores (Goal Attainment).

Analysis of Goal Changes and Attainment in Target Goal Scores for Yo Yo Test

In the process of recording participant Goal Scores for the post-test Yo Yo test, the Control Group recorded their goals in the paper-based diary, shared that goal with the researcher only and was given until the end of the first week of the intervention program to make and record any changes to that goal. Not a single participant of the Control Group changed their Goal Score. By contrast, it was observed using the SPUTNIK administration sub-system that 6 (six) of the participants of the Intervention Group changed their Goal Scores by the end of the first week of the Intervention Program and in each case, the Goal Score was decreased. Upon investigation of intra-group online communication between the Intervention Group members, there was a consistent agreement between all ten members of the group that having had the chance to visually analyse and share their physiological performance data they needed to modify their Goal Scores. This occurrence while of behavioural note did not translate to a significant correlation between Goal Changes and Yo Yo post-test scores as shown in **Appendix F**.

Analysis of mean and standard deviation for Yo Yo post-test scores as a percentage of Target Goal Scores shows μ_0=97.93 and μ_1=101.34 with $ð_0$=5.81 and $ð_1$=2.33. **Appendix F** provides a box-plot analysis of Yo Yo Post-test Scores (Yo Yo test two) as a percentage of Goal Score that clearly shows the variance of scores *within* the intervention group (X) was significantly less than the variation within the scores of the control group(C). This may indicate the influence of group cohesion on normalizing the Goal Score within the intervention group and minimal goal conflict within the group.

There was a strong, positive correlation of 0.52, (p=0.037) between the adherence rates measured as the Number of Sessions completed and the Yo Yo post-test score expressed as a percentage of the Target Goal Score (Goal Attainment).

It appears that the higher the adherence of the participants the closer their attainment of their Target Goal Scores. This is reinforced by the simple regression analysis, detailed in **Appendix G** that shows that a 1% increase in the number of sessions is associated with a 7% increase in goal attainment. What is indeterminate in this relationship is the nature and extent of the influence of the group normative dynamic and the socialisation of the physiological data using the SNS on this goal setting and attainment behaviour. This may warrant further investigation and analysis.

From the analyses then, the null hypothesis, H_0 can be rejected and we can conclude the alternate hypothesis, H_a holds true and socialising physiological data will have a statistically significant effect on the attainment of Target Goal Scores in a Yo Yo Intermittent Recovery test (Level Two) for participants in a HIIT intervention program.

Null hypothesis 3 H_0

This asserts there will be a median difference of zero and adherence to the HIIT program will have no significant effect on the score achieved by participants in the modified Yo Yo Intermittent Recovery Test (Level Two).

It has been established that the control group exhibited significantly less adherence to the intervention than the intervention group. As well, from the Mann-Whitney U test analysis there is a significant difference, $p<0.05$ in Yo Yo test performance between the groups. It can be concluded the greatest improvement in test scores were attained by the intervention group which also had the highest adherence to the HIIT intervention program. This is consistent with the findings of the Mann-Whitney U test detailed in Figure 7. These reveal that the Yo Yo pre- and post-tests results show the intervention group, with its higher adherence had a greater improvement in Yo Yo test performance (Sum of $Ranks_1$ 48.50 to 63.00) than the control group which showed a decline in performance (Sum of $Ranks_0$ 87.50 to 73.00).

Discussion

Summary

The primary purpose of the study was to determine if the use of a BSN: SNS technology system could affect adherence to a HIIT program specific to improving the RSA of field hockey players. A secondary purpose was to understand any effect this same technology could have on goal setting and attainment of target goal scores in a modified Yo Yo Intermittent Recovery Test (Level Two). Thirdly, the study looked to observe and measure any change in performance improvement in the Yo Yo Intermittent Recovery Test (Level Two) that could be attributed to the HIIT itself.

There was no study identified from the review of literature that dealt specifically with the use of a garment-based BSN that incorporated a heart rate monitor and an accelerometer as well as an advanced SNS-based management system for socialising and analysing data. Any studies completed previously have focused on sedentary sample populations and used basic pedometers as the ETM and walking as the preferred intervention protocol. No work had been done until now using the technology and a sound study design with competitive athletes.

Complying with training program adherence levels is characteristic of the individual responsibility of team and individual athletes alike. It is common practice for athletes to be responsible for the self-monitoring and management of their physical conditioning throughout the year; training with a group is not always possible. According to Harris, (2010), in a review of the research there was evidence athlete adaptation deprecated when they trained in an unsupervised state due to a decrease in training frequency and intensity. The employment of any effective aid that supports adherence by athletes to training programs in an unsupervised setting should be seriously considered. Research consistently reveals that field hockey is a game typified by extremely intense repeat sprint activities performed intermittently; it places high demand on the interval endurance capacity of the athlete; Aziz,Chia, & The (2000). The prescriptive approach used by practitioners to help the athlete meet these demands is typically based on intense interval training. The risk that an unsupervised field hockey athlete will fail to fully adhere to a training program is exacerbated by the sheer intensity of the workload inherent in hockey-specific HIIT prescriptions; the

more intense the exercise program, the lower the adherence; (Sallis, 1994; Weinberg & Gould, 2011).

To counter the potentially negative effects on adherence of training alone and being forced to meet the demands of HIIT-based prescriptions, coaching and conditioning practitioners are urged to better understand the role of health behaviour models and group dynamics as they pertain to improving athlete motivation and adherence. This knowledge couldbe applied in concert with an appreciation of the potential application of remote physiological performance data collection and socialisation using BSN-SNS technology similar to that used in this study because if technology can simulate social proximity and interaction then cohesion, relatedness and support may follow, (Mueller & Agmanolis, 2005).The findings herein reveal a positive relationship between the use of BSN-SNS technology and adherence to an intense exercise program used by field sport athletes and (ii) a strong correlation between this subsequent adherence and exercise program goal attainment.

Null hypothesis 1 H_0

This asserted that there would be a median difference of zero and that the Socialisation of Data with BSN-SNS technology will have no significant effect on adherence to the HIIT intervention program.

The null hypothesis was rejected as the study showed clearly that adherence levels were much higher in the group of participants that were able to socialise their physiological data using the BSN-SNS technology. The tests showed that there was a highly statistically significant difference between the groups, $U=9.00$, $p<0.05$ (two-tailed) such that the level of adherence shown by the intervention group (mean rank=11.38) exceeded the control group (mean rank=5.63). There was also a strong, positive correlation) of (p=0.037) between the adherence rates measured as the Number of Sessions completed and the Yo Yo post-test score expressed as a percentage of the Target Goal Score (Goal Attainment). Regression analysis showed that the intervention group did 70% better on average for adherence than the control group.

It would appear through analysis of the objective data and observation of the online discussions that the intervention group was able to capitalize on the dynamics of group cohesion and strong social support to galvanize their training efforts and adhere to the demands of the HIIT program. Supporting qualitative data by way of post study interviews

points to the accessibility, functionality and ease of use of the technology as a contributing factor to the direct support of cohesion and support within the group. This bonding carried through to the execution of the training sessions themselves as the intervention group primarily but not exclusively trained together for around sixty percent of the duration of the intervention. Group training at no stage included all of the participants at one time but rather saw training done in pairs, groups of four and alone. In the group situations, participants explained that they were able to share roles so that one individual could oversee the session details of work, rest and recovery timings in accordance with the details of the HIIT intervention.

The markedly superior adherence levels of the intervention group may possibly have stemmed from a combination of the following mechanisms; group cohesion and support underpinned by training together, satisfaction of relatedness needs seen as essential in the SDT health behavioural change model, public posting of goals and implementation of the Expression and Reveal and Compare native patterns of persuasion, Fogg, Weiksner& Liu .(2008). Each of these mechanisms has been implemented through the BSN-SNS technology which was used as the independent variable in the study and used to positive effect although no instrumentation was done of the SPUTNIK codebase to yield clear data on implementation levels. Further investigation is required to substantiate this postulation.

In examining the SPUTNIK system log, there was some online dialogue between intervention group members that point to the positive role played by the technology in aiding adherence; “ nice to know where I’m at with the program 24/7”, “ hell these graphs don’t lie”, “ it’s good not to have to guess how much I’ve done and how hard I am actually working”, “ to see it on the phone in front of your eyes is cool”. It is clear that the technology had a positive influence to what extent this improved adherence with or without the group training effect could not be determined completely with the study design employed. If resource constraints had not been an issue then it would have been optimal to include a Control Group that was allowed the option of training together, this may have helped underpin the salience of the technology in yielding the superior adherence or perhaps point to the training together feature as the predominant influence on adherence levels.

The rapid creation of group identity and a unified purpose was made clear in the casual online social dialogue on the SPUNTIK system by members of the intervention group. The participants committed to schedule all training sessions at a convenient venue in advance and

ensure attendance. This group-based training which was the predominant behaviour played an important part in the performance many sessions, particularly given the challenge inherent in the program's intensity. However, not all training sessions conducted by the intervention group were group-based. No measure was taken of the exact split of solo versus group training by these participants but in discussion with group members, group training became more prevalent after 2 weeks of the intervention program and may have on what evidence could be gleaned from the SPUTNIK system file account for around sixty percent of all training done by the intervention group. Cohen, Knight & Ejsmond-Frey (2010), determined when groups perform exercise together there are exhibited forces that can magnify the physiological benefits of exercise to each member. They showed that rowers in a college rowing crew when training together experienced a greater endorphin surge than with a similar training regime that was performed alone. The research team used pain threshold as the assay for determining the relative levels of endorphin uptake. Given this finding, consistent with anecdotal comments from the participants in the study; "it was great to train together; it didn't feel as hard as interval sessions on your own", "we were able to push and encourage each other", "it didn't seem to hurt as much as training on your own", this group dynamic may have made the tough interval sessions less daunting and painful for the intervention group. Interestingly, the positive effect of this dynamic did not waiver as the program progressed, the group met their twice weekly intervention commitments unfailingly. This is consistent with the findings of Spink & Carron (1992), who revealed that as a group's social cohesion grows so does its ability to adhere to a fitness-oriented exercise program. Fraser & Spink, (2002), also found that cohesion and social support variables both contributed to the successful prediction of attendance at exercise programs.

The findings of the current study were consistent with those of earlier studies that used various sensor systems, mobile technology and the Facebook SNS, all of which ascertained a positive effect on exercise adherence through deployment of the technologies. Hurling, et al., (2007) evaluated the impact of a physical activity program based on the Internet, Bluetooth-enabled wrist-worn accelerometers and mobile phones with 77 healthy adults over a 9 week period. The work showed a fully automated web-mobile phone based monitoring, motivation and social support system can increase and maintain the level of physical activity in healthy adults. Foster et al., (2010) used a BSN-Facebook technology framework for their study investigating the socialisation of walking activity online. They found the participants with socially-enabled access who could view their colleagues step data and make comparisons and

comments had significant increase in step activity over the other participants in the non-social condition. This finding indicated a positive relationship between social interaction over an online social network and the motivation to increase physical activity in a work-based setting. With the evidence produced by our study, this positive relationship has been extended to include high intensity exercise applications for athletes.

The technology platform chosen for the intervention group was selected to some extent for its inherent functional support for key elements of the SDT health behaviour model. However, the SPUTNIK system was not instrumented to determine the exact level of usage of specific components of SDT. This is an opportunity for a later development and study effort. The SPUTNIK system seemed to provide elements of both the social and environmental conditions that allowed the satisfaction of the three basic psychological needs (autonomy, competence and relatedness to others) which in turn helped promote the internalisation of positive exercise behaviours so they were engaged in autonomously; and if the SDT model is correct, these behaviours are more likely to be maintained in the long term Ryan et al., (1997. The system may help provide the conditions to satisfy these basic needs through the social technology mechanisms of group support, interactive dialogue and real-time messaging, graphical and text-based performance data and knowledge transfer. However, there needs to be a more detailed study conducted into how, specifically how the system satisfied each of the three basic psychological needs as defined by the SDT model. Interestingly, both groups were afforded the same level of coach autonomy support, having received the same instruction and training knowledge. The autonomy support provided in the study not only included freedom of choice (although the intervention prescription was mandatory for all, the participants could choose when and where to train), it also precluded any external pressure or controls; Ryan et al., (1997).

In terms of ability, the standardised fitness testing showed clearly that both groups were not significantly different from the outset. If anything, the control group had the slightly higher base level of fitness; μ_0=24.65, μ_1=23.06. Using SPUTNIK, the intervention group was able to form a unified group that actively supported and encouraged one another to adhere to the HIIT program; they trained together, and shared their physiological performance data. They were able to learn how to best cope with the HIIT program and perform at their best. By contrast, the control group trained in isolation, they also uniformly failed to record any physiological training data; the only information they wrote into their paper-based diary was whether or not a session was completed in full. These participants had no social support from

their peers and as a result clearly struggled to adhere to the program, maintain motivation, attain their goals and progress their fitness levels. This is unsurprising given the findings of Burke, Carron,& Eys, (2006), who ran a study with university-age students to determine their most and least preferred physical activity context from the choices given of exercising (a) in a structured exercise class,(b) with others outside of a structured exercise class, (c) alone in an exercise setting, and (d) completely alone. The setting selected as the most preferred was (b) exercising with others outside of a structured exercise class; the least preferred setting was (d) exercising completely alone. Our participants share a similar background and demographics to the group examined by Burke, Carron, & Eys; those in the control group struggled in a training environment devoid of peers and peer support.

Fogg, Weiksner, & Liu, (2008) used a Grounded Theory approach to identify six patterns of persuasion evident on the Facebook SNS, four of which they attribute to being native to Facebook; namely, Provoke and Retaliate, Reveal and Compare, Expression and Group Exchange. These patterns play an important role in the rate of adoption of software written to run on the Facebook SNS, the functional efficacy of these programs and their inherent behavioural mechanisms. The SPUTNIK component may successfully implement two of the key patterns of persuasion identified by Fogg et al., and in so doing seems to have acted to enhance group cohesion and support and with it, the encouragement of positive exercise behaviours. The two patterns implemented are the Expression pattern and the Reveal and Compare pattern. The Reveal and Compare pattern facilitates the sharing of experiences and provides the ability to compare and usually rank others based on agreed attributes. The mechanisms work to encourage personal interactivity thereby creating an environment for social validation. This is reinforced by the frank and open exchange of feedback around the validation process. With SPUTNIK, Reveal and Compare is implemented by the History Details of Friends function that enabled clear and simple comparison of performance and progress across the group. SPUTNIK also provided a basic implementation of the Expression pattern, in the form of the instant graphic analysis and contextual notes produced for each training session. This served as an individual artefact that each participant could publish and share as an expression of their physical efforts. This facility encouraged interaction, support and relatedness.

As Fogg et al.,(2008), point out, "much like Goffman's original performance analogy for impression management, the Facebook user is an actor shaped by the environment and audience trying to provide performance consistent with his or her goals (p.157)." It is clear

that Facebook provides a stage for shaping how others perceive an individual, affecting how that individual perceives them and potentially moulding their identity. In the study, the system allowed the intervention group participants to freely share their goals and performance and interact around this data, expressing feelings, views and advice. In effect, the technology used in the study may have assisted in impression management, Piwinger & Ebert, (2001) (pp1-2) defined impression management as a "goal-directed conscious or unconscious process in which people attempt to influence the perceptions of other people about a person, object or event; they do so by regulating and controlling information in social interactions". Given the uniform attainment of their goals and continually positive reinforcement shared amongst the group, the intervention group participants in the study were possibly able to positively affect their own impression management within the group; the functionality of the SPUTNIK and SNS systems could have aided and abetted this. The exact part that may be played by a BSN-SNS system and its users' impression management requires further, more extensive and rigorous examination.

Null hypothesis 2 H_0

This asserts there will be a median difference of zero and that the Socialisation of Data with BSN-SNS technology will have no significant effect on the attainment of Target Goal Scores.

This hypothesis was rejected by the findings which revealed a strong, positive correlation (p=0.037) between the adherence rates measured as the Number of Sessions completed and the Yo Yo posttest score expressed as a percentage of the Target Goal Score. It has been established that the intervention group had the highest adherence rate. Further analysis of the Yo Yo Post-test Scores as a percentage of Target Goal Score showed the variance of scores *within* the intervention group showed less variance than the scores within the control group. This may indicate an influence of group cohesion on normalizing the Target Goal Score within the intervention group and a lack of goal conflict.

The behaviour of both groups around the original goal setting activity was revealing. Both groups were asked to set their own individual target goal score that they were looking to attain in the post-test after they had been told their pre-test score. They were also afforded the opportunity to change this goal after completion of the first week of the HIIT program. No member of the control group changed their target goal score. By contrast, six of the participants of the intervention group changed their target goal scores by the end of the first week of the HIIT program. In each instance of a participant opting to change, the target goal

scores were decreased. Analysis of intra-group SNS comments between the intervention group members revealed a consensus reached by the members of the group that having had the chance to visually analyse and share their physiological performance data online and experience the effort needed to complete a HIIT session, they needed to consider modifying their target goal scores. The sharing of the training performance data and the social interaction around the data between group members may have been instrumental in clarifying the self-efficacy of group members with respect to the completion of the prescriptive program. Subsequently, there appears to have been an evolution of a collective efficacy within the intervention group once the efficacy of the individual members was measured and understood. Collective efficacy is defined as the group members' shared belief that they can execute a specific task successfully (Bandura, 1997). As the intervention group outperformed the control group in terms of exercise adherence, there may have been a stronger sense of collective efficacy and with it a greater persistence in the face of the challenge of the HIIT program.

In analysing the content of social interactions amongst the intervention group, there was no evidence of goal conflict. which could account for the narrow variance of target goal scores attained by the intervention group; whereby the SD of the YoYo post-test as a percentage of Target Goal Score for the control group was $ð_0$=5.81, the intervention group yielded a $ð_1$=2.33. It is possible that the low level of conflict around goal setting and adjustment reflected the learning of the group about their performance capabilities, normalisation of their group-based training process and a consensus of their collective efficacy. Lee (1988), found that a low level of goal conflict was a contributing factor in improving team performance in a group of women field hockey players and strongly related to the team's game winning percentage. This group normalization of goals and the consistency of attainment across the intervention group could reflect the synergistic influence of Facebook-based persuasion patterns and impression management along with the power of real-time physiologic feedback from the SPUTNIK system. Rigorous qualitative measurement and analysis tools need to be used to fully understand any detailed treatment of goal conflict; use of such tools was beyond the scope of this pilot study.

The SPUTNIK system provided the intervention group with the facility to set and change individual goals as well as visually track and analyse actual training session performance data against target goal scores. This immediate real-time feedback on performance could have influenced the goal score changes and attainment of the target goal scores. Mauger, Jones, &

Williams, (2011), investigated the influence of providing comparative performance feedback to cyclists completing a 4 kilometre time trial on pacing and performance. They found the provision of accurate performance feedback data is beneficial to the performance of an exercise session particularly at the start and end of a session. It would seem the ability to collect feedback data, gauge performance, assess and alter goals, monitor progress against target and socialise this information amongst a group of team mates online on a SNS assists in exercise performance and the attainment of fitness performance goals.

As the control group participants were restricted to private goal setting only there was no opportunity for them to post their goals before the group or to gather peer feedback on their target goal score. In sport settings, public posting of goals is often combined with goal setting to improve the performance of athletes (Ward & Carne, 2002). Again, it would seem that the intervention group was advantaged by both the power of the group to positively influence goal levels and adherence behaviour and the ability to set, adjust and share goals dynamically online. As a result they performed better and were more successful in attaining their target goal scores.

An interesting observation was the dearth of physiological data recorded by the control group; they all had state-of-the-art heart rate monitors to help them understand their performance in relation to the HIIT program. These participants either had no interest in recording the data (although they all admitted to wearing the monitors and viewing the output on the dedicated watch devices) or failed to see the value in the data. In sharp contrast was the abundance of performance data collected by the SPUTNIK system and acted upon by the participants in the intervention group. Although they did not have to use a pen and paper to record data, these participants still had to setup their SPUTNIK system for each session, upload the data to Facebook then import the data and type in training session ID code and context narrative; they did this unfailingly each and every time. This difference in data management between the groups may be due to the automated functionality of the intervention group technology and its relatively greater appeal by way of look, feel and features.

Null hypothesis 3 H_0

This asserts there will be a median difference of zero and adherence to the HIIT program will have no significant effect on the score achieved by participants in the modified Yo Yo Intermittent Recovery Test (Level Two).

The null hypothesis is rejected by the findings which showed the greatest improvement in test scores was attained by the intervention group which also had the highest adherence to the HIIT intervention program. This is consistent with the findings of the Mann-Whitney U test detailed in Figure 7. in **Appendix G**. These reveal that the Yo Yo pre and post-tests results show the intervention group, with its higher adherence had a greater improvement in Yo Yo test performance (Sum of $Ranks_1$ 48.50 to 63.00) than the control group which showed a decline in performance (Sum of $Ranks_0$ 87.50 to 73.00).

The improvement in performance of the intervention group gained by adhering to the HIIT program is consistent with the application of the protocol to a variety of sports, including those such as Australian Rules football that are based on repeat sprint activity and intermittent maximal exertion. Hunter, et al., (2011), showed intermittent peak and peak running speeds along with a 300m shuttle performance run improved significantly amongst Australian Rules footballers subjected to a 4 four week repeated sprint training program.

Should this study be repeated, it may be beneficial for the researchers to adopt a more comprehensive physiological testing regime in order to gauge a more detailed analysis of the comparative performance between test groups. Although HIIT has been the subject of comparatively extensive research in cycling (McDougall et al. 1998; Laursen et al., 2005) to determine its benefits and specific improvements in physiological measures, it has not been as prolific a source of investigation for intermittent field sports, in particular field hockey. The one major study of the physiological factors involved in RSA in hockey players was conducted by Bishop, Lawrence & Spencer (2003). They found the strongest predictor of RSA ability in elite female hockey players was plasma pH. There is then a potential to apply a tailored HIIT program focused on improving RSA ability in elite hockey players with the study using plasma pH as the benchmark measure of the efficacy of the prescription.

Limitations

1. We cannot absolutely guarantee that participants in the Control Group did not communicate with other members of the study to discuss the study and their respective performances. This communication would include communication of individual Yo Yo test results; knowledge of which may or may not have affected goals set and adjusted, motivation and performance.
2. We cannot guarantee the degree of completion of individual sessions provided by the Intervention Program in the Control Group. The SPUTNIK system showed clearly the exact session content of each participant in the Intervention Group to ensure relative completion was recorded accurately.
3. Despite providing training and ethical conduct rules of engagement and the background supervision of the researcher we could not absolutely guarantee fully compliant behaviour from all participants of the Intervention Group outside of the SPUTNIK for Facebook software application and within the general Facebook operating environment.
4. We had no control over participant injury or illness occurrences during the study.
5. We had no control over player and squad training and playing commitments that may have affected the quality of performance of any of the sessions required to be completed in the Intervention Program.
6. We could not dictate the level of effort any participant applied to the completion of the individual training sessions or standardised tests.
7. We had no control over the integrity, reliability or availability of the Telstra® mobile phone network required to publish sensor-based performance data by the Intervention Group to the SPUTNIK for Facebook software.
8. We could not affect or influence any goals set by participants.

Significance

The findings of this pilot study have potential significance to the application of BSN-SNS technologies to any exercise adherence problem; recreational and elite athlete preparation as well as health and well-being management of at risk population segments such as cardio-vascular disease patients and Type II diabetes sufferers. The work done builds on the robust base of previous investigation with ETMs, Facebook and mobile computing along with the relevant elements of social psychology and has moved it forward in the direction of a better understanding of adherence to intense exercise prescriptions amongst athletes using BSN-SNS technology. The findings have direct ramifications for coaches and allied health practitioners overseeing athlete training prescriptions with athletes training in remote locations; there is potential for them to use the BSN-SNS technology to optimise adherence and provide a framework for group cohesion and support, virtually.

The study has produced evidence that group-based training and peer support are essential for providing the optimum environment of social support and relatedness to significant others while complying with the demands of HIIT. This environment also may allow an athlete to improve their fitness and better understand the application of physiological performance feedback and group values on goal setting and attainment. Researchers in the domain of exercise rehabilitation could apply knowledge gleaned from the study to ascertain athlete-patient cardio-vascular fitness levels in a non-invasive manner. They could also investigate the viability of the technology for monitoring fitness levels of athletes in remote locations prior to their re-engagement with normal conditioning regimes following exercise rehabilitation and assist in the assessment of performance readiness. Having determined an energising effect on training adherence of socialising physiological performance on a social networking site there arises some potential for an opportunity to overhaul the way in which exercise programs are prescribed, measured, communicated, analysed and adjusted in the fitness industry. The findings of this study however do not provide sufficient evidence to promote the use of any or all components of the SDT model into health programmes en masse.

Further research

A simple and valuable extension to the findings of this study would be the addition of a study group that trained alone but used the intervention technology. At this stage, we have established to some extent the impact on adherence when the technology is used for group-based training and online socialisation, analysing its use in a train alone state would be advantageous.

The study as it stands is limited; it needs expansion across additional problem domains; exercise, clinical health and industrial health and safety. There may be sufficient merit in the study to justify extension of the design itself and the underpinning BSN-SNS technology to accommodate a broader range of physiological data collection both from on the body and from the environment including clinical devices. This is essential for understanding its application to other domains. Determining if the same results are forthcoming from a similar study with females may be worthy of further investigation. There may be merit in determining a true cost benefit analysis of the technology as a tool for distributed high performance sports networks that rely on regional and geographically remote nodes to administer programs and support athletes.

The study has shown the importance of ensuring any SNS-based software that is used to socialise exercise data implements key elements of the SDT health behaviour change model; further work is required to understand how a similar system can accommodate and support each of the three basic psychological needs and their satisfaction as espoused by this model. The Facebook patterns of persuasion warrant further analysis and would require functional extension of the SPUTNIK system or similar to fully implement these patterns.

A broader and deeper quantitative analysis of the patterns of behaviour and the size of effect of the social support dynamics offered by BSN-SNS technology warrants further study. If this analysis is applied to injury-recovery rehabilitation in an isolated setting it could provide a framework for improved service delivery and quality of outcomes. Emotional health benefits such as connectedness, relatedness and inclusion for those in rural and remote areas could accumulate from BSN-SNS technology application in public health, for example, patients with cardio-vascular disease or high risk profiles can be monitored at a 24/7 level and receive real time peer and advisory support with no need for face to face intervention. It could be a worthwhile investigative challenge to determine if such promise can be realised in practice and if so, how and why.

Conclusion

The quantitative analysis of the data collected from participants in this study suggest that BSN-SNS technologies such as SPUTNIK could provide a platform for improving exercise adherence in team sports requiring high intensity interval training protocols. The same technology could be extended and tailored to play a positive role in managing adherence in workplace and community health interventions. Although this thesis is based on a small sample size, it has yielded encouraging results. There is sufficient potential in the technology and approach to encourage extension of the physiological measurements gathered to include additional sensors such as respiration rate, skin temperature, blood pressure and blood glucose levels. Similarly, software functionality should be extended to better accommodate persuasion patterns and a more comprehensive implementation of health behavioural change models. The promise of the findings is also sufficient enough to warrant a more robust and extensive study design, quantitative and qualitative analyses.

With exercise now accepted as a valid prescription for the maintenance of good health and the prevention of common illnesses, there is an opportunity for researchers and practitioners to generate methods, processes and technology that can cost effectively deliver exercise as medicine to the public. This study could provide a small part of the body of knowledge needed to make such a delivery feasible.

References

Adie, J., Duda, J., & Ntoumanis, N. (2008). Autonomy support, basic need satisfaction and the optimal functioning of adult male and female sport participants: A test of basic needs theory. *Memory and Emotion, 32*(3), 188-199.

Almagro, B., Saenz-Lopez, P., & Moreno, J. (2010). Prediction of Sport Adherence through the influence of autonomy supportive coaching among Spanish adolescent athletes. *Journal of Sports Science and Medicine, 9,* 8-14.

Annesi, J. (1999). Effects of minimal group promotion on cohesion and exercise adherence. *Small Group Research, 30*(5), 542-557.

Anshel, M., & Seipel, S. (2009). Self-monitoring and selected measures of aerobic and strength fitness and short-term exercise attendance. *Journal of Sport Behavior, 32*(2).

Aziz A, R., Chia, M., & The, K.C.(2000). The relationship between maximal oxygen uptake

and repeated sprint performance indices in field hockey and soccer players. *Journal of Sports Medicine & Physical Fitness, 40,* 195–200.

Bandura, A., & Cervone, D. (1983). Self-evaluative and self-efficacy mechanisms governing the motivational effects of goal systems. *Journal of Personality and Social Psychology, 45*(5), 1017-1028.

Bandura, A. (1997*). Self Efficacy: The exercise of control*. W.H. Freeman Company: U.S.A.

Bandura, A. (2000). Exercise of human agency through collective-efficacy. *Current Directions in Psychological Science*. *9*(3), 75-78.

Bangsbo, J., Iaia, M., & Krustrup, P. (2008). The Yo-Yo intermittent recovery test: A useful tool for evaluation of physical performance in intermittent sports. *Sports Medicine, 38*(1), 37-51.

Bartlett, J., Close, G., Maclaren, D., Gregson, W., Drust, B., & Morton, J. (2011) High-intensity interval running is perceived to be more enjoyable than moderate-intensity continuous exercise: Implications for exercise adherence. *Journal of Sports Sciences, 29*(6), 547-553.

Bollen, K. & Hoyle, R. (1990). Perceived cohesion: A conceptual and empirical examination. *Social forces*, *69*(2), 479-504.

Boyd, D. & Ellison, N. (2007). Social network sites: Definition, history, and scholarship. *Journal of Computer-Mediated Communication*, *13*(1), 210-230.

Brady, S., Dunne, L. E., Tynan, R., Diamond, D., Smyth, B., & O'Hare, G. M. P. (2005). *Garment-based monitoring of respiration rate using a foam pressure sensor*. doi:10.1109/ISWC.2005.23

Burgomaster, K., Howarth, K., Phillips, S., Rakobowchuk, M., MacDonald, M., McGee, S. & Gibala, M. (2008). Similar metabolic adaptations during exercise after low volume sprint interval and traditional endurance training in humans. *The Journal of Physiology*, *586*(1), 151-160.

Burke, S. M., Carron, A. V. & Eys, M. A. (2006). Physical activity context: Preferences of university students. *Psychology of Sport and Exercise*, *7*:1–13.

Carron, A. V., Brawley, L. R. & Widmeyer, W. N. (1998). The measurement of cohesiveness in sport groups. In J. L. Duda (Ed.), *Advances in sport and exercise psychology measurement* (pp. 213-226). Morgantown, WV: Fitness Information Technology

Cartwright, D. & Zander, A. (1968). *Group Dynamics*. London: Tavistock.

Chatzisarantis, N. & Hagger, M. (2007). *Intrinsic motivation and self-determination in exercise and sport*. Champagne, IL: Human Kinetics.

Christensen,U., Schmidt, L., Budtz-Jørgensen E. & Avlund, K.(2006).Group cohesion and social support in exercise classes: Results from a Danish intervention study. *Health Education Behavior*, *33* (5), 677-689.

Cohen, E., Knight, N. M. D. R. I. & Ejsmond-Frey, R. (2010). Rowers' high: Behavioural synchrony is correlated with elevated pain thresholds. *Biology Letters, The Royal Society*, *6*(1), 106-108.

Consolvo, S., Everitt, K., Smith, I. & Landay, J. A. (2006). Design requirements for technologies that encourage physical activity. doi:10.1145/1124772.1124840

Courneya, K.S. & McAuley, E. (1995). Reliability and discriminant validity of subjective norm, social support, and cohesion in an exercise setting. *Journal of Sport and Exercise Psychology*. *17*, 325-337.

Coyle, S. (2009, June). Textile-based wearable sensors for assisting sports performance. Paper presented at the BSN 2009 - Body sensor networks conference Berkely. Retrieved from http://doras.dcu.ie/4502/

Coyle, S. (2010). BIOTEX-biosensing textiles for personalised healthcare management. *IEEE Transactions on Information Technology in Biomedicine, 14*(2), 364-370.

Deci, E. & Ryan, R. (2000). The "What" and "Why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, *11*(4), 227-268.

Deci, E. & Ryan, R. (2002). *The Handbook of Self-Determination Research*. New York: University of Rochester Press.

Deci, E., Ryan, R. & Williams, G. (1996). Need satisfaction and the self-regulation of learning. *Learning and Individual Differences*, *8*(3), 165-183.

Dishman, R. (1991). Increasing and maintaining exercise and physical activity. *Behavior Therapy*, *22*(3), 345-378.

Edge,J., Bishop, D., Goodman,C. & Dawson, B. (2005). Effects of high- and moderate-intensity training on metabolism and repeated sprints. *Medicine & Science in Sports & Exercise*, *37*(11), 1975-1982.

Ellison, N., Steinfield, C., & Lampe, C. (2007). The beneits of Facebook ‘‘friends’’: Social. *Journal of Computer-Mediated Communication, 12*, 1143-1168.

Fairclough, S., Gilleade, K. (2010, June). Physiology as XP: Body blogging to victory. Paper presented at BIOS-PLAY workshop at Fun and Games, 2010, Leuven, Belgium. Retrieved from http://www.ljmu.ac.uk/ENG/Researchgroups/MORG/73213.htm

Fogg, B.J.,Weiksner, G.M., & Liu, X.(2008) In H. Oinas-Kukkonen et al. (Eds.) Six patterns for persuasion in online social networks. *PERSUASIVE 2008* (pp. 151–163). Oulu, Finland.

Foster, D., Linehan, C., Kirman, B., Lawson, S., & James, G. (2010). *Motivating physical activity at work: Using persuasive social media for competitive step counting*. Retrieved from http://portal.acm.org/citation.cfm?doid=1930488.1930510

Fraser, S. N., & Spink, K. S. (2002). Examining the role of social support and group cohesion in exercise compliance. *Journal Of Behavioral Medicine*, *25*(3).

Gagne, M. (2003). Autonomy support and need satisfaction in the motivation and well-being of gymnasts. *Journal of Applied Sport Psychology*, *15*(4), 372-390.

Garcia, A., & King, A. (1991). Predicting long-term adherence to aerobic exercise: A comparison of two models. *Journal of Sport & Exercise Psychology*, *13*(4), 394-410.

Garland, D., & Barry, J. (1990). Personality and leader behaviors in collegiate football: A multidimensional approach to performance. *Journal of Research in Personality*, *24*(3), 355-370.

Gatizoulis, L., & Iakovidis, I. (2007). Wearable and portable eHealth systems. *Engineering in Medicine and Biology Magazine, IEEE, 26*(5), 51-56.

Gibala, M., & McGee, S. (2008). Metabolic adaptations to short-term high-intensity interval training: A little pain for a lot of gain? *Exercise & Sport Sciences Reviews*, *36*(2), 58-63.

Gormley, S.E., Swain, D.P., High, R., Spina, R.J., Dowling, E.A., Kotipalli, U.S., & Gandrakota, R.(2008) Effect of intensity of aerobic training on VO2max. *Medicine & Science in Sports & Exercise*, *40*(5).

Halpern, D. (2004). *Social capital*. London: Polity.

Harris, B. A.,(2010). iPods-a surrogate coach for junior and subelite athletes: New ideas based on a review of the literature. *Journal of Strength & Conditioning Research, 24*(12):3507-19.

Hayes, S. (1985). Self-reinforcement effects: An artifact of social standard setting. *Journal of Applied Behavior Analysis*, *18*, 201-214.

Helliwell, J., & Putnham, R. (2004). The social context of well-being. *Philosophical Transactions of the Royal Society London*, *359*, 1435-1446.

Hunter, J., Obrien, B., Mooney, M., Berry, J., Young, W., & Down, N. (2011). Repeated sprint training improves intermittent peak running speed in team-sport athletes. *Jounral of Strength and Conditioning Research*, *25*(5), 1318-1325.

Hurling, R., Catt, M., Boni, M. D., Fairley, B. W., Hurst, T., Murray, P., Richardson, A., & Sodhi, J. S. (2007). Using internet and mobile phone technology to deliver an automated physical activity program: randomized controlled trial. *Journal Of Medical Internet Research*, *9*(2).

Jennings, G. (2010). Hypertension and adherence to physical activity programs—a sticky matter! *British Journal of Sports Medicine, 44*(14), 994-997.

Jones, F., Harris, P., Waller, H., & Coggins, A. (2005). Adherence to an exercise prescription scheme: The role of expectations, self-efficacy, stage of change and psychological well-being. *British Journal of Health Psychology*, *10*(3), 359-378.

Jovanov, E., Milenkovic, A., Otto, C., & de Groen, P. C. (2005) A wireless body area network of intelligent motion sensors for computer assisted physical rehabilitation. *Journal of NeuroEngineering and Rehabilitation*, *2*(6), 1-10.

Kendall, L., Hartzler, A., Klasnja, P., & Pratt, W. (2011). *Descriptive Analysis of Physical Activity Conversations on Twitter*. CHI 2011 ACM 978-1-4503-0268-5/11/05.

King, A. (1992). Determinations of physical activity and interventions in adults. *Medicine & Science in Sports & Exercise*, *24*(6), 221-236.

Knight, J.F., & Baber, C (2005). A tool to assess the comfort of wearable computers. *HUMAN FACTORS*, *47* (1), 77–91.

Lam Po Tang S., & Stylios G. K. (2006). An overview of smart technologies for clothing design and engineering. *International Journal of Clothing Science and Technology*, *18*(2), 108-128.

Latham, G., & Locke, E. (2007). New developments in and directions for goal-setting research. *European Psychologist*, *12*(4), 290-300.

Laursen, P., Shing, C., Peake, J., Coombes, J., & Jenkins, D. (2005). Influence of high-intensity interval training on adaptations in well-trained cyclists. *Jounral of Strength and Conditioning Research*, *19*(3), 527-533.

Lee, C., (1988). The relationship between goal setting, self-efficacy,

and female field hockey team performance. *Journal of Sports Psychology*, *20*,147-161.

Lenhart, A., Purcell, K., Smith, A., & Zickuhr, K. (2010, February 3). *Social Media and Young Adults*. Retrieved from http://www.pewinternet.org/Reports/2010/Social-Media-and-Young-Adults/Summary-of-Findings.aspx

Lindstrom, M., Laaksolathi, J. (2006)Affective diary – Designing for bodily expressiveness and self-reflection. Proceedings from CHI 2006, April 22-27, 2006, Montreal, Quebec, Canada. Paper retrieved from http://www.interaction-design.org/references/conferences/proceedings_of_acm_chi_2006_conference_on_human_factors_in_computing_systems.html

Lopes, A. (2010). *Nike+*. Retrieved from http://hci.uma.pt/courses/socialweb/projects/2010.nikeplus.paper.pdf

Macdougall, J., Hicks, A., Macdonald, J., McKelvie, R., Green, H., & Smith, K. (1998). Muscle performance and enzymatic adaptations to sprint interval training. *Journal of Applied Physiology*, *84*(6), 2138-2142.

McAuley, E., Jerome, G. J., Elavsky, M. S., Marquez, D. X., & Ramsey, S. N. (2003). Predicting long-term maintenance of physical activity in older adults. *Preventive Medicine*, *37*(2), 110-118.

Mallet, C (2008). Understanding motivation to enhance the quality of coaching. *Sports Coach*, *28*(3).

Mauger, A.R., Jones, A. M., & Williams, C. A. (2011). The effect of non-contingent and accurate performance feedback on pacing and time trial performance in 4-km track cycling. *British Journal of Sports Medicine*, *45*(3), 225-229

Mehdizadeh, S. (2010). Self-presentation 2.0: Narcissism and self-esteem on Facebook. *Cyberpsychology, behavior and social networking*, *13*(4), 357-364.

Mueller, F., & Agmanolis, S. (2005). Sports over a distance. *ACM Computers in Entertainment*, 3(3), 1-11.

Moller, A., Deci, E., & Ryan, R.. (2006). Choice and ego-depletion: the moderating role of autonomy. *Personality and Social Psychology Bulletin*.*32*(8),1024-1036.

Munson, S., Lauterbach, D., Newman, M., & Resnick, P. (2010), Happier together: Integrating a wellness application into a social network site. In Proceedings of Persuasive Technology: 5th International Conference, PERSUASIVE 2010, Copenhagen, Denmark, June 7-10, 2010. Edited by Thomas Ploug, Per Hasle. Paper retrieved from http://www.sciweavers.org/conference/persuasive-2010

Murphy, S. (2012, May 5th). Half of consumers smartphones while working out. Report posted to http://mashable.com/2012/05/04/smartphones-while-working-out/

O'Brien, B.J. , D Grindrod, D.,Paton, C.D.,Knez, W.L., (2006). Six minute walk distance is greater when performed in a group than alone. *British Journal of Sports Medicine*, 40(10), 876-877.

Oka, R., King, A., & Young, D. (1995). Sources of social support as predictors of exercise adherence in women and men ages 50 to 65 years. *Womens Health*, *1*(2), 161-175.

Oman, R., & King, A. (2000). The effect of life events and exercise program format on the adoption and maintenance of exercise behaviour. *Health Pscyhology*, *19*(6), 606-612.

Oman, R., & McAuley, E. (1993). Intrinsic motivation and exercise behavior. *Journal of Health Education*, *24*, 232-238.

Park, N., Kee, K., & Valenzuela, S. (2009). Being immersed in social networking environment: Facebook groups, uses and gratifications, and social outcomes. *Cyberpsychology and Behavior*, *12*(6), 729-733.

Paton, C., & Hopkins, W. (2004). Effects of high-intensity training on performance and physiology of endurance athletes. *Sportscience*, *8*, 25-40.

Paursen, P., Shing, C., Peake, J., Coombes, J., & Jenkins, D. (2005). Influence of high-intensity interval training on adaptations in well-trained cyclists. *Journal of Strength and Conditioning Research*, *19*(3), 527-533.

Pearce, N., & Davey Smith, G. (2003). Social capital the key to inequalities in health? *American Journal of Public Health*, *93*(1), 122-129.

Perri, M. G., Anton, S. D., Durning, P. E., Ketterson, T. U., Sydeman, S. J., Berlant, N. E., and Martin, D. A. (2002). Adherence to exercise prescriptions: Effects of prescribing moderate versus higher levels of intensity and frequency. *Health Psychology*, *21*,(5), 452–458.

Piwinger, M., & Ebert, H. (2001). "Impression management: Wie aus niemand jemand wird". *in: Bentele, Guenther et al. (Ed.), Kommunikationsmanagement: Strategien, Wissen, Lösungen*. Luchterhand, Neuwied.

Rees, T., & Hardy, L. (2004). Matching social support with stressors: Effects on factors. *Psychology of Sport and Exercise, 5*, 319-337.

Ring-Dimitriou, S., von Duvillard, S., Stadlmann, M., Kinnunen, H., Drachta, O., Muller, E., and Peak, K. (2007). Changes in physical fitness in moderately fit adults with and without the use of exercise telemetry monitors. *European Journal of Applied Physiology*, *102*(5), 505-513.

Ritterbrand, L., Thorndike, F., Cox, D., Kovatechev, B., & Gonder-Frederick, L. (2009). A behavior change model for Internet interventions. *Annals of Behavioral Medicine*, *38*, 18-27.

Ryan, R., Frederick-Recascino, C., Lepes, D., Rubio, N., & Sheldon, K. (1997). Intrinsic motivation and exercise adherence. *International Journal of Sport Psychology*, *28*, 335-354.

Sallis, J. (1994). Influences on physical activity of children, adolescents, and adults or determinants of active living. *Physical Activity and Fitness Research Digest, 1*(7) 1-7.

Sebire, S. J., Standage, M. & Vansteenkiste, M., (2009). Examining intrinsic versus extrinsic exercise goals: Cognitive, affective, and behavioral outcomes. *Journal of Sport & Exercise Psychology, 31* (2), 189-210.

Sheldon, K., Abad, N., & Hinsch, C. (2011). A two-process view of Facebook use and relatedness need-satisfaction: Disconnection drives use, and connection rewards it. *Journal of Personality and Social Psychology*, *100*(4), 766-775.

Sherwood, N., & Jeffrey, R. (2000). The behavioral determinations of exercise: Implications for physical activity interventions. *Annual Review of Nutrition*, *20*, 21-44.

Spencer, M., Bishop, D., Dawson, D., & Goodman, C. (2005). Physiological and metabolic responses of repeated-sprint activities: Specific to field-based team sports. *Sports Medicine*, *35*(12), 1025-1044.

Spink, K., & Carron, A. (1992). Group cohesion and adherence in exercise classes. *Journal of Sport & Exercise Psychology*, *14*(1), 72-86.

Swain, D. P., High, R., Spina, R. J., Dowling, E. A., Kotipalli, U. S., & Gandrakota, R. (2008). Effect of intensity of aerobic training on VO2max. *Medicine And Science In Sports And Exercise*, *40*(7), 1343.

Tudor-Locke, C., Chan, C., & Ryan, D. (2004). Health benefits of a pedometer-based physical activity intervention in sedentary workers. *Preventive Medicine*, *39*(6), 1215-1222.

Vansteenkiste, M., Matos, L., Lens, W., & Soenens, B. (2007). Understanding the impact of intrinsic versus extrinsic goal framing on exercise performance: The conflicting role of task and ego involvement. *PSychology of sport and exercise*, *8*(5), 771-794.

Ward, D., Evenson, K. R., Vaughn, A., Rodgers, A. B., & Troiano, R. (2005). Accelerometer use in physical activity: Best practices and research recommendations. *Medicine & Science in Sports & Exercise*, *37*(11), 582-588.

Ward, P., & Carne, M. (2002). Effects of posting self-set goals on collegiate football players' skill execution during practice and games. *Journal of Applied Behavior Analysis*, *35*(1), 1-12.

Ward, P., & Carne, M. (2002). Effects of posting self-set goals on collegiate football players' skill execution during practice and games. *Journal of Applied Behavior Analysis*, *35*(1), 1-12.

Webber, K., Gabriele, J., Tate, D., & Dignan, M. (2010). The effect of a motivational intervention on weight loss is moderated by level of baseline controlled motivation. *International Journal of Behavioral Nutrition and Physical Activity*, *7*(4), 1-9.

Weinberg, R. (2010). Making goals effective: A primer for coaches. *Journal of Sport Psychology in Action*, *1*(2), 57-65.

Weinberg, R., & Gould, D. (2011). *Foundations of Sport and Exercise Psychology*. Champagne, IL: Human Kinetics.

Wood, R., & Locke, E. (1990). Goal setting and strategy effects on complex tasks. *,Research in organizational behavior*, *12*, 73-109.

Wilson, P., Rogers, W., Blanchard, C. M., & Gessell, J. (2003). The Relationship Between Psychological Needs, Self-Determined Motivation, Exercise Attitudes, and Physical Fitness. *Journal of Applied Social Psychology*, *33*(11), 2373-2392.

Yang, G. (2006). *Body sensor networks* (p. 11). London: Birkhäuser.

Appendix A

Plain Language Information Statement

PROJECT TITLE:	Body-Blogging: A Randomized Controlled Trial of Interval Training Interventions using Body Sensors
PRINCIPAL RESEARCHER:	Dr. Brendan O'Brien (03) 5327 9677 Dr. Christopher Mesagno (03) 5327 6136
OTHER/STUDENT RESEARCHERS:	Mr. Daryl Foy NZ 036858440; VIC 0390164140 Mob: 021332778

You are invited to participate in a study currently being conducted within the School of Human Movement and Sport Sciences at the University of Ballarat. The research is being undertaken by research student Daryl Foy under the supervision of Senior Lecturer Dr. Brendan O'Brien and Dr. Christopher Mesagno.

This study examines the use of body sensor gathered socially networked physiological data which are physiological vital signs that are collected by a shirt with sensors, sent to a computer application on a mobile phone and from there published to a fit-for-purpose software program that runs on Facebook . The study then aims to determine if the use of this technology has a positive effect on adherence to an interval training-based intervention program and performance in a standardised Multi Stage Fitness (or Yo-Yo) Test. This test is based on a simple 20 metre repeated shuttle run based on a temp determined by a computer program used to manage the test process. Additionally the study will investigate the effect of peer support and information disclosure on athlete goal setting and motivation for training performance. It is hoped that this study will demonstrate the practical benefits of using

mobile body blogging as a training intervention aid and provide an indication of the effects of a sports-specific interval training program on performance in a standardised Multi Stage Fitness (or Yo-Yo) Test.

You will be asked to participate in two Multi Stage Fitness (Yo Yo Level 2) Tests; one just prior to and one at the completion of a five week sports-specific interval training program during the months of October and November, 2011. The fitness testing will help determine your aerobic fitness. The procedure for this testing has you running on a field with a small grid of three lines; 20 meters and 2.5 metres apart marked with cones. You start your run test on or behind the middle line, and begin running 20 m when instructed by the CD provided by the researcher. You then turn and return to the starting point when signalled by the recorded beep. There is an active recovery period of 5 seconds interjected between every 20 metre (out and back) shuttle, during which you must walk or jog around the other cone and return to the starting point. A warning is given when you do not complete a successful out and back shuttle in the allocated time and you will finish the test the next time you do not complete a successful shuttle. Your (raw) score is calculated as the total distance covered before you are unable to keep up with the recording. The test usually takes between 2-20 minutes.

Once you complete your testing you will take part in a normal 6 week sports specific endurance training program whereby you will be asked to record your goals and physiological data after each session. This training program, tailored to the specific needs of elite hockey players will replace the existing physical training components of your current program. You will be trained on how to use the technology required. At the completion of the six week training program you will be asked to complete an online survey about your goals, motivations and experiences during the program period.

As a result of your participation in this study you will be provided with before and after Multi Stage Fitness (Yo Yo Level 2) test results and your $_{e}$VO2 Max (a standardised measure of cardiorespiratory fitness) results to enable a better understanding of your fitness levels and the effects of the sports-specific interval training program. If you experience any psychological distress upon receipt of your results, you will be referred to an appropriate counselling service, or Lifeline NZ (0800-543-354).

Participation in this study is voluntary, refusal to participate requires no explanation and participants are entitled to withdraw their consent to participate and discontinue participation at any time until data is processed without prejudice. Throughout the study you will be able

to preview results and transcripts, and withdraw any of your data during or at the end of the tests if you feel uncomfortable.

The data collected for this study will remain completely confidential, subject to legal limitations, with participants' names wholly removed from any data. The results of your individual fitness tests will be made available to you, researchers involved in the study and potentially academic journals; however any form of participant identification will be removed from results before dissemination. Data collected from this study will be stored securely for a minimum of five years upon which it will be securely destroyed by the principal researcher. If you require follow up support or assistance following this study you can contact any of the researchers involved and they will attempt to meet your needs or refer you to someone who can.This research is being funded by a grant provided by the Telematics Society of Victoria (Australia). This study has also been approved by the Human Research Ethics committee of the University of Ballarat.

If you have any questions, or you would like further information regarding the project titled **(Body-Blogging: A Randomized Controlled Trial of Interval Training Interventions using Body Sensors)**, please contact the Principal Researcher, **(Dr. Brendan O'Brien)** of the School of **(Human Movement & Sport Sciences)**:

PH: (03) 5327 9677

EMAIL: b.obrien@ballarat.edu.au

OR

Daryl Foy

PH: 036858440 0390164140 Mob: 021332778

EMAIL: darylfoy@students.ballarat.edu.au

Should you (i.e. the participant) have any concerns about the ethical conduct of this research project, please contact the University of Ballarat Ethics Officer, Research & Graduates Studies Office, University of Ballarat, PO Box 663, Mt Helen VIC 3353. Telephone: (03) 5327 9765, Email: ub.ethics@ballarat.edu.au

CRICOS Provider Number 00103D

Appendix B

UNIVERSITY OF BALLARAT

SCHOOL OF Human Movement and Sport Science

Assent to Participate in Research

Title of Project A Randomized Controlled Trial of a Facebook-Based Interval Training Intervention using Body Sensors

Supervisors Dr.Brendan O'Brien

Dr. Chris Mesagno

Researcher Daryl Foy

I have read all of the information provided that explains the objectives of the study, the processes to be used and outcomes expected.

I have been able to ask questions and have them answered to my satisfaction.

I understand the security for privacy mechanisms and will adhere to these.

I understand I can withdraw at any time from this study without penalty and all record of my participation will be destroyed.

I understand I can consult the researcher and supervisor if I have any concerns about the study process, the training program, and the systems and technology being used.

I understand I can access the LIFELINE counselling service if any aspect of my participation in this study warrants emotional support over and above family, peers, supervisory and research staff.

I agree to participate in this research study.

Participant's Name _____

Participant's Signature _____

Participant's Contact Details

(if appropriate) _____

Date _____

Appendix C

Students of Ballarat Hockey Club

15 Bedggood Court

Ballarat, Victoria 3356

www.studentsofballarathockeyclub.weebly.com

To whom it may concern

My name is Cheyne Hackett. I am the senior coach of the Students of Ballarat Hockey Club. The club has been approached by Daryl Foy, a Masters candidate to gauge the interest of senior club players in participating in research for his thesis research through the University of Ballarat. The interest by players is high, and as coach, and on behalf of the Hockey Club, I am happy to approve the players' participation.

I am aware of the nature of the study:

'Body-blogging: A randomised controlled trial of interval training interventions using body sensors'.

I have read the study proposal and the outline of the research and understand the processes, precautions, constraints, planned outcomes and contingencies that have been put in place to ensure the study is conducted in a safe, fair and professional manner.

Students of Ballarat hockey club will provide the 20 participants from its senior teams. It is understood that the research study will be conducted over a 5-week period in Ballarat commencing after October 20th 2011.

Yours sincerely

Cheyne Hackett

President

Students of Ballarat Hockey Club
0434614688

Appendix D

Yo-Yo Intermittent Recovery Test Level 2 (YYIRTL2)

Table 3. *The speeds and accumulated distances for each stage of the Yo Yo Intermittent Recovery Test (Level 2).*

Stage	Speed level	Speed km/hr	No. shuttles (2 x 20m)	Total distance covered (m)
1	11	13.0	1	40
2	15	15.0	1	80
3	17	16.0	2	160
4	18	16.5	3	280
5	19	17.0	4	440
6	20	17.5	8	760
7	21	18.0	8	1080
8	22	18.5	8	1400
9	23	19.0	8	1720
10	24	19.5	8	2040
11	25	20.0	8	2360
12	26	20.5	8	2680
13	27	21.0	8	3000
14	28	21.5	8	3320
15	29	22.0	8	3640

Note: Adapted from Bangsbo, J, Iaia, M, & Krustrup, P. (2008). The Yo-Yo Intermittent Recovery Test: A Useful Tool for Evaluation of Physical Performance in Intermittent Sports. *Sports Medicine*, *38*(1), 37-51.

Intervention program

Hockey players are required to repeat high intensity sprints in quick succession when playing. If the physiological and metabolic responses of repeated-sprint protocols are to be specific

and relevant to field-based team sports, then the sprint and recovery durations should replicate the movement patterns of these sports; Spencer, M, Bishop, D, Dawson, D, & Goodman, C. (2005).

From the same study, the average maximal sprint duration is 4 seconds. These findings have directly guided the structure of the capacity-predominant Intervention Program where the focus is on speed endurance improvement of field hockey players. This capacity-focused program aims to extend the length of time that the anaerobic alactic system contributes to game related running activity. The longer we can make the alactic system contribute the less the anaerobic lactic system needs to contribute, helping to keep lactic acid and keep fatigue levels lower. Although the Intervention Program is limited to a 5 week period only, studies completed by (Burgomaster, et al., 2008) suggests that high-intensity interval training is a time-efficient strategy to increase skeletal-muscle oxidative capacity and induce specific metabolic adaptations during exercise that are comparable to traditional endurance training.

Work Period

Anaerobic training is always done as intervals. The duration of the work is typically under 10 seconds, Spencer, M, Bishop, D, Dawson, D, & Goodman, C. (2005).

Rest Period

In order to stress the energy system and force it to adapt, the rest period is by necessity less than that used in field hockey speed and agility work. The rest period is 6-10 times the duration of the work period to start and slowly moves towards 4 times the work interval. In other words if you do a 10 second sprint your rest time will be 50-60 seconds. It is important in this or any other type of interval work that the pace or power output for each work segment of the interval is consistent. Once the participants can get through a full training session with less than a 10% speed drop from their first interval to their last interval they can start decreasing the rest period.

Work Volume

Work volume is measured in total work time. A volume of 4-6 minutes is the goal for serious hockey players. This is accomplished by doing several sets totalling 60s - 80s of work per set. Each sprint is a repetition so if you were doing 10 second sprints you would need to do 6 of them, with appropriate rest between sprints, to complete one set, as a guide, if you were doing 20 second sprints you would do 3 per set. At the end of each set you will take a 5- 10 minute

break, where you can walk or jog slowly, to help remove the lactate you have produced. Then you repeat the whole process 4-6 times. A sample workout can be seen in Table 3 below.

Because speed endurance training can be so demanding, session duration has been kept to a maximum of 20-30 minutes. Rest intervals should consist of active recovery exercises such as walking or jogging slowly on the spot.

Table 2. *Work volumes and rest volumes*

	Volumes
Work	6-10+s
Rest	6-10 times the work interval down to 4 -6 times the work interval at the end of the program
Pause	5 to 10 minutes
Volume per set	60 – 80 seconds work

Table 3. *HIIT Intervention Program Schedule*

Week	Session	Work	Rest	Pause
1	1	10 x 8s	60s	6 minutes
		12 x 6s	40s	6 minutes
		8 x 10s	60s	6 minutes
2	1	12 x 5s	40s	6 minutes
		10 x 3s	30s	6 minutes
		8 x 5s	40s	6 minutes
	2	12 x 8s	75s	6 minutes
		12 x 6s	40s	6 minutes
		10 x 10s	70s	6 minutes
3	1	12 x 5s	30s	5 minutes
		12 x 3s	30s	5 minutes
		10 x 5s	40s	5 minutes
		6 x 12s	75s	5 minutes
	2	12 x 8s	60s	5 minutes
		12 x 6s	35s	5 minutes
		12 x 10s	65s	5 minutes
		6 x 12s	75s	5 minutes
4	1	10 x 5s	25s	5 minutes
		10 x 3s	25s	5 minutes
		12 x 5s	30s	5 minutes
		12 x 3s	20s	5 minutes
	2	12 x 8s	60s	5 minutes
		12 x 6s	30s	5 minutes
		12 x 10s	60s	5 minutes
		12 x 8s	65s	5 minutes
5	1	10 x 5s	25s	4 minutes
		10 x 3s	25s	4 minutes
		12 x 5s	30s	4 minutes
		12 x 3s	20s	4 minutes
		10 x 8s	50s	4 minutes
	2	12 x 8s	50s	4 minutes
		12 x 6s	30s	4 minutes

Week	Session	Work	Rest	Pause
		12 x 10s	50s	4 minutes
		6 x 12s	60s	4 minutes
		10 x 6s	30s	4 minutes

Appendix E

Technology used as the study intervention

Intervention Group

This group consisted of ten (10) participants used a SPUTNIK DataSkin with Bluetooth to collect:

- heart rate
- linear accelerometer data including:
- cadence
- distance
- speed

This group was issued with a SYMBIAN O/S mobile handset that is correctly specified to run the SPUTNIK mobile software. Each handset used a limited pre-paid data plan to enable publishing of physiological performance data to SPUTNIK on Facebook and to download the SPUTNIK mobile software application. The study provided the Intervention Group participants with the necessary pre-paid mobile data plans. All members of this group, after selection and initial training in the use of the technology enabled each other participating member of the Intervention Group to operate as a Facebook Friend for the duration of the training program only. The choice to continue on as Facebook Friends after the study was left to the participant. Ethical conduct was discussed with these participants prior to their use of the technology in the program to reduce any incidences of cyber bullying or negative social conduct within the group. The researcher also operated as a Facebook Friend to each participant without playing active role in online group dynamics. This connection was provided as a technical support role to help answer technology queries not as a social mediation role.

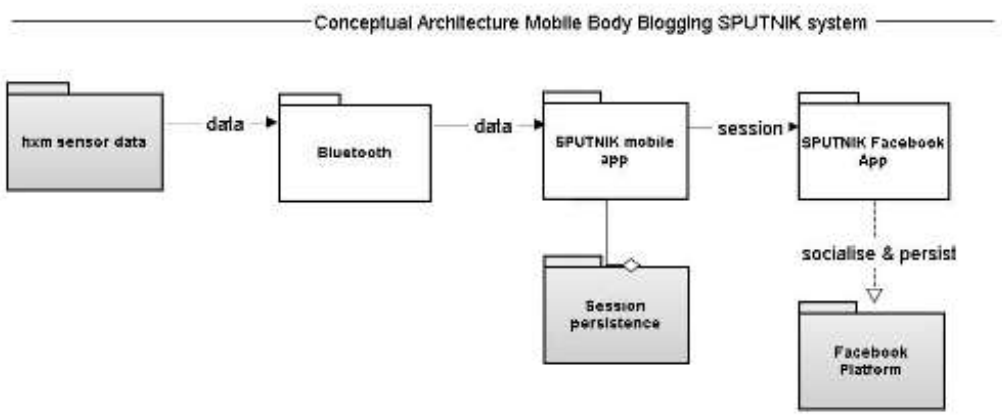

Figure 3. *The conceptual architecture for the SPUTNIK mobile body blogging system.*

Privacy

The SPUTNIK for Facebook system is an extremely secure and robustly private technology that can only be accessed and used by the participants.

To gain access to the SPUTNIK on Facebook software an individual requires:

1. A unique random number generated system ID they can only get when the technology owners provide them with access to the SPUTNIK settings server.
2. Along with this unique number, each Bluetooth (aka hxm) transmitter has a unique number only accessible to the participant after they download the SPUTNIK mobile software which they can only get via step 1.
3. The hxm unique number is only known after the SPUTNIK mobile software is installed.
4. Each hxm number is then uniquely linked to the mobile number and the unique SPUTNIK for Facebook random number generated ID in 1.
5. In order to publish physiological data collected by the hxm on the DataSkin, the participant must have a valid Facebook log-in.
6. Once the participant has set-up the technology they and only they can further calibrate the level of data access they give other participants to their performance data; as

shown in Figure 4 (screen capture from the live SPUTNIK for Facebook software application):

Figure 4. *SPUTNIK Facebook application: Settings screen.*

This multi-tiered security system is well in excess of any common social networking standard and safeguards the privacy of every individual participating. The existing SPUTNIK for Facebook online community had no physical, logical or virtual access to the Intervention Group participants. The study participants used a separate logical server instance.

The SPUTNIK DataSkin

This comprises a Turbo Merino® tank top with ergonomically integrated Zephyr Technology hxm heart rate monitor and accelerometer. The transmitter collates the on-body physiological data and makes it available via Bluetooth to a paired mobile phone. The transmitter is charged via a USB cable to a USB charger or to a free USB port on a laptop or PC.

The SPUTNIK for Mobile Software Application

This application collects data from the Zephyr Technology hxm Bluetooth transmitter and manages each discrete recorded exercise or training unit as a Session. The software is responsible for finding the transmitter at the start of each Session, as well as providing Session Recording, Display of in situ Data and Session Publication to Facebook functionality. When the units is first setup, or on cases of other users wearing the unit, SPUTNIK for

mobile ensures the integrated system (hxm unit and mobile software) is correctly tuned to measure distance, speed and cadence via a Calibration function.

The SPUTNIK for Facebook Software Application

Import Session Function

The Session data from the participants, once published over GPRS by the SPUTNIK for mobile application is imported into the SPUTNIK for Facebook application. At this point the participant is obliged to assign the Session to a particular training type-location known as a ROUTE. For the sake of the study, a naming convention was employed to assist ease of analysis of the server log files with the Administration sub-system as follows:

Participant Initials – Week Number – Session Number

e.g. Paul William Mason - PJMW1S2

Figure 5. *SPUTNIK Facebook application: Dashboard screen.*

Dashboard Screen

This screen provides a simple and clear snapshot of what the participant has been up to and how they have performed. The bar graph at the top allows a view of the most recent SESSIONS via any combination of the basic measurement variables. These are altered simply by clicking on any of the radio buttons beneath the bar graph; the graph itself will update quickly. To the left of the bar graph there are shown the 5 most recent SESSIONS listed. If you click on any of these you are taken to the HISTORY screen where a full, very detailed graphic analysis of the session is provided along with the facility to make comments and to read the comments of those FRIENDS that the participant has provided access to on SPUTNIK.

Below the list and bar graph there is a GOALS section on the left and a (Cumulative) Statistics section that lists overall performance to date: by week, month and year. The GOALS can be changed at any time.

Figure 6. *SPUTNIK Facebook application: Goal setting.*

History Screen

This screen option is selected from the Main Menu to facilitate a DRILL DOWN into a very detailed analysis of each and every Session that that the participant has published to SPUTNIK. If the participant has, through the SETTINGS Main Menu option, allowed access to all of their Session data to one or more Friends, the Friends have access the History details of every Session they have published. The Friend is here able to Add a Comment on the Session and begin an interactive social dialogue. Each participant has the option to have their Comment posted to their own Facebook Profile.

Figure 7. *SPUTNIK Facebook application: History screen.*

Progress Screen

The participant chooses this option from the Main MENU in order to track their target performance on a key physiological variable as a GOAL against their actual performances in Sessions of the Intervention Program. They can select any of the radio buttons on either side of the bottom of the graph to change the data viewed. If and only if they have set a goal for the measure and there are completed sessions will a YELLOW GOAL line display.

Figure 8. *SPUTNIK Facebook application: Progress screen.*

Appendix F

Univariate and bivariate analysis of results

Yo Yo Pre-test Scores Analysis: boxplot

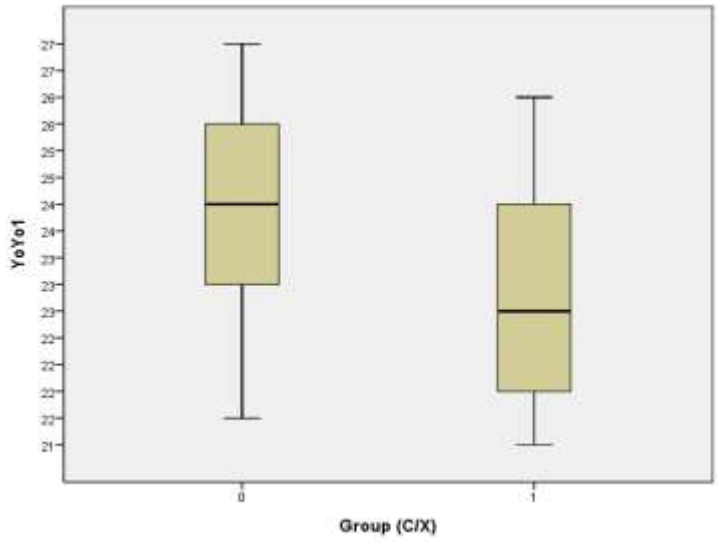

Figure 9. *Yo Yo Pre-test participant scores box plot analysis.*

Yo Yo Pre and Post Test Comparison and Analysis

Means

Table 4 *Yo Yo Pre and post-test comparison and analysis of means.*

Group (C/X)		YoYo1	YoYo2
O (N=8)	Mean	24.65	24.56
	Std Deviation	1.60	2.19
I (N=8)	Mean	23.06	24.29
	Std Deviation	1.58	1.49
Total (N=16)	Mean	23.86	24.43
	St Deviation	1.74	1.82

Medians

Table 5 *Mann-Whitney U test comparative performance in Yo Yo intermittent recovery test scores from pre-test to post-test.*

Group (C/X)		YoYo1	YoYo2
O (N=8)	Mean Rank	10.94	9.13
	Sum of Ranks	87.50	73.00
I (N=8)	Mean Rank	6.06	7.88
	Sum of Ranks	48.50	63.00

Table 6 *Test statistics*

	YoYo1	YoYo2
Mann-Whitney U	12.50	27.00
Wilcoxon W	48.50	63.00
Z	-2.05	-0.53
Asymp Sig.(2-tailed)	0.04	0.60
Exact Sig. [2*(1-tailed Sig)}	0.04[a]	0.65[a]

Note: a) Not corrected for ties

b) Grouping variable Group C/X

Mann-Whitney U Test: Analysis of Adherence

Table 7 *Mann-Whitney U Test shows median difference between groups: adherence as measured by the Number of Sessions completed.*

Group (C/X)	N	Mean Rank	Sum of ranks
O	8	5.63	45.00
I	8	11.38	91.00
Total	16		

Table 8 *Test Statistics*[b]

	Num Sessions
Mann-Whitney U	9.00
Wilcoxon W	45.00
Z	-2.44
Asymp.Sig. (2-tailed)	0.02
Exact Sig. [2*(1-tailed Sig)]	0.012[a]

Note a) Not corrected for ties

b) Grouping variable Group (C/X)

Correlation analysis – group adherence

Table 9 *Pearson Correlation: group membership and adherence.*

		Group(C/X)	Num Sessions
Group(C/X)	Pearson Correlation	1	0.65*
	Sig. (2-tailed)		0.007
	N	16	16
Num Sessions	Pearson Correlation	0.65*	1
	Sig. (2-tailed)	0.007	
	N	16	16

Note a) Correlation is significant at the 0.01 level (2-tailed).

Adherence and Yo Yo Test Performance: Mann Whitney U

Table 10 *Significance of adherence and Yo Yo test performance*

Test Statistics[b]	YoYo1	YoYo2	Num Sessions
Mann-Whitney U	12.50	27.00	9.00
Wilcoxon W	48.50	63.00	45.00
Z	-2.05	-0.53	-2.44
Asymp.Sig. (2-tailed)	0.04	0.60	0.02
Exact Sig. [2*(1-tailed Sig)]	0.04[a]	0.65[a]	0.02[a]

Note a) Not correlated for ties

b) Grouping variable Group (C/X)

Analysis of Target Goal Score Changes and Attainment

Pearson correlation

Table 11 *Correlation between Number of Goal Changes and Yo Yo post-test scores*

		Num_Goal_changes	YoYo2
Num_Goal_changes	Pearson Correlation	1	0.15
	Sig. (2-tailed)		0.59
	N	16	16
YoYo2	Pearson Correlation	0.15	1
	Sig. (2-tailed)	0.59	
	N	16	16

Boxplot analysis – variance in Yo Yo posttest scores expressed as a percentage of Target Goal Score

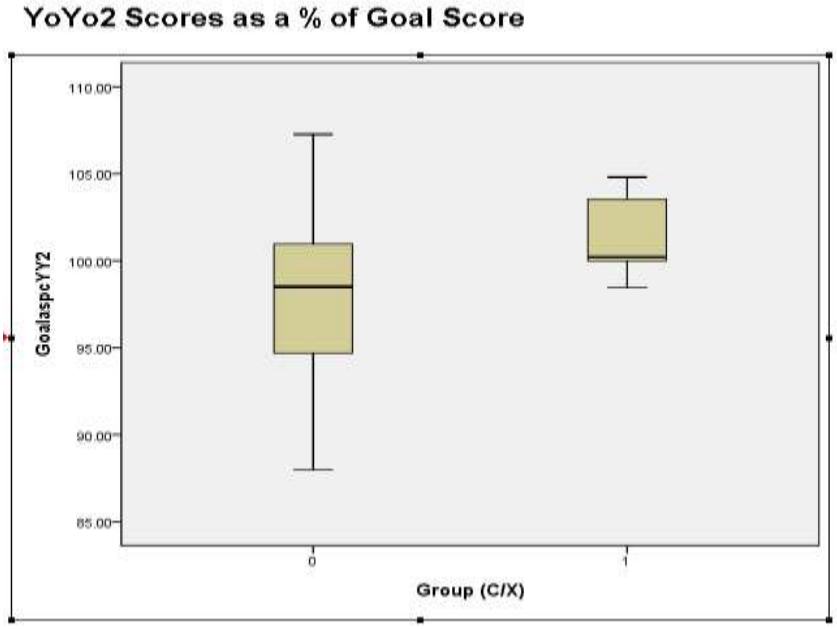

Figure 10. *Variance in YoYo2 posttest scores as a percentage of goal scores.*

Pearson correlation

Table 12 *Correlation between adherence measured by Number of Sessions completed and Yo Yo post-test scores measured as a percentage of the Goal Score set by participants*

		Goal as a % YoYo2	Num Sessions
YoYo2 as % Goal	Pearson Correlation	1	0.52[a]
	Sig. (2-tailed)		0.04
	N	16	16
Num Sessions	Pearson Correlation	0.52[a]	1
	Sig. (2-tailed)	0.04	
	N	16	16

Note a) Correlation is significant at the 0.05 level (2-tailed)

Appendix G

Multivariate analysis of posttest data

Posttest analysis with regression

Table Regression on dummy variables: Num_Sessions as the dependent variable

Table 13. *Summary Output – Regression statistics*

Regression Statistics	
Multiple R	0.746
R Square	0.557
Adjusted R Square	0.489
Standard Error	0.300
Observations	16

Table 14 *Analysis of Variance*

ANOVA

	df	SS	MS	F	Significance F
Regression	2	1.471	0.735	8.174	0.005
Residual	13	1.169	0.090		
Total	15	2.640			

Table 15

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-5.648	3.302	-1.711	0.111	-12.781	1.485
log(YoYo2)	2.238	1.032	2.168	0.049	0.008	4.467
GroupCX	0.533	0.150	3.544	0.004	0.208	0.857

Process

In order to address the non-Gaussian distribution of the data generated by the small sample size, the process used in the analysis was to (i) randomise the data set using the "=rand()" function, (ii) take natural logs of the three continuous variables using the "=ln" function, (iii) Use MS-Excel- regression function and (iv) use the =exp()" function to take the anitlog of the CX group coefficient, subtract one from it and multiply it by 100. The dependent variable is log(num sessions), the explanatory variables are log(yy2) and group (cx where c denotes control group and x denotes the intervention group). The log(num sessions) and log(yy2) are continuous and expressed in logarithmic or non-linear. The group cx is dichotomous, assuming values of only 0 or 1 and linear (non-logarithmic). The goal was to express the Num Sessions dependent variable as a function of the two explanatory variables in order to determine if there was a statistically significant relationship between Num Sessions and each of the two.

Analysis and interpretation

The table shows that the coefficients on the explanatory variables are significant at the 5% level; 0.049 on Yo Yo 2 score and 0.003 on group membership. What is shown is that the CX group did 70% better on average for adherence (measured as Num_Sessions) than the control group. The use of the intervention was effective. As explained above, the interpretation of the coefficient on the group (CX) variable using the technique is 0.703366 or 70.34%; Gujurati & Porter (2008).

Table Regression on dummy variables: Yo-Yo-_posttest score as % of target goal (Goal Attainment)score as the dependent variable

Table 16. *Summary of output*

Regression Statistics	
Multiple R	0.623
R Square	0.388
Adjusted R Square	0.294
Standard Error	0.040
Observations	16

Note log(yy2goal)=f (log(numsessions, group)

Table 17 *Analysis of variance*

ANOVA

	df	SS	MS	F	Significance F
Regression	2	0.013	0.007	4.127	0.041
Residual	13	0.021	0.002		
Total	15	0.034			

Table 18

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	4.475	0.050	90.035	0.000	4.368	4.583
log(Num sessions)	0.071	0.032	2.256	0.042	0.003	0.140
GroupCX	-0.001	0.026	-0.039	0.969	-0.056	0.054

Process

This was identical to the first regression process.

Analysis and interpretation

Using this technique it could not be shown that there was a relationship between the level of goal attainment and group membership, although there is a relationship between goal attainment and the number of sessions. A 1% increase in the number of sessions is associated with a 7% increase in goal attainment (expressed as the Yo Yo posttest score as a percentage of the target goal score measure). Note that the Adjusted r^2 and Significance F figures show a relatively poor model fit but still hold sufficient statistical validity.